



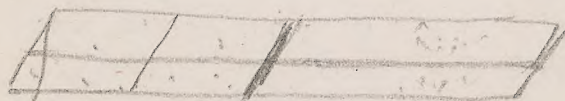
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REFERENCE

Given by Dr. W. H. Wahl



Wyle Ware,
Hdly. 169.

Vorlesungen -
über

Anorganische Chemie.

vorgetragen
von

Priv. Rath Dr. Busse

1 Lecture 1.st

Chemistry belongs to the great
class of the Natural sciences
There are two great categories of
Matter.

1st General or Universal } Properties
2nd Special } of matter.

a) General Properties.

General { 1st Raum Erfüllend } with Univ. At. }
Principles { 2nd Impenetrability. } Strac. + Tragheit. }

b) Special Properties.

The greatest difference exists
between the various products
of nature, viz: - Plant. Animal
Mineral &c. These differen-
ces can be of two kinds -
1st Non-molecular -
2nd Molecular.

1st Nonmolecular prop^{ties}
are such as depend upon
the Outward form of the body.
2nd Molecular - are such as

are independent of form, or
mutual relations.

Non-Molecular — prop's.
Animal- Plant - possesses
various parts. Organs. Such
as roots - stem - vessels - cells
leaves, etc; These are destroyed
& lost by destruction of it - &
with them the plant ceases to
be a plant. Granite - maybe
divided mechanically - until
we have before us separate
particles of SiO_2 . Orthoclase & Mica
- it is then no longer Granite.
This class of Properties lie be-
yond the domain of Chemistry
Descrip. Nat. Sci. are dependent
upon them - viz. Zoology Botany
Crystallography, etc)

Molecular Properties.
These are such as are independent.

of the outward form of a substance + are as indestructible as matter itself. It may change the form of matter at pleasure - but these properties, remain, + form the groundwork for the differences in matter.

These molec. props. are of 2 kinds

Molec. - 1st Physical. 2nd Chemical.

ular Physical molecular properties. Proper- are such as depend upon ties the form + relative positioning of the molecules. J.B.

Ex a Cube of NaCl when struck with a hammer gives us the same form in infinitely small pieces.

So with CaOCO_2 in R.

The NaCl is, however still NaCl

" CaOCO_2 " " CaOCO_2

The substance H_2O . at various temp's. assumes 3 dif-

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ferent forms, Sol. liq. + Gas, but
in all these changed conditions the
substance is H_2O ; - the position of the
molecules relative to one another
is a different one - but the mole-
cules are still the same, + the sp.
identity of the substance H_2O is not
lost \rightarrow ~~nor can~~ mechanical Illus-
trations affect it.

Chemical Mol. Prop's,
Depend upon ~~an~~ inherent differ-
ences in matter. (peculiar + internal)
independ. of form or condition,
or position of molecules.

Illust. diff. bet. Chem. + Phys. Prop's. Ex
Pt wire in the flame glows - but
on cooling shows no alteration.
Mg. wire - resembles it - but is
converted with great light + heat
into a white substance called
 MgO . its sp. identity as Mg has been

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last. This different behaviour depends upon an inherent difference in matter - & upon these depend those differences which we express - when we say - Iron is different from Lead. & cannot be changed to lead. If a body resist all the means we bring

An to bear upon it to separate it into
Elem - several bodies - if, after all our
ent efforts the body is unchanged -
we call that body an Element. if
not we call it a compound.
Chemistry is the science
which teaches us to know of the
Chemical as well as Phys. changes -
which matter undergoes - & which
treats of the forces, by which these
changes are brought about.

As the first Element to be treated
of is Oxygen - & it combines with
Every other Element it is best

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to take a general view of all
the Elements in order, to have
an idea of their properties. Their
number as yet, is about 65. Divis-
Their divisions mentioned. Various ions
kinds of divisions. Best division
that depending upon Electrical
differences. Metals + Metalloids.
Sub-divisions into Groups -
possessing analogous Chem. Charac.
The use of Symbols - + the advan-
tage of the same.

Short description of Metalloids.

Oxygen.

A gas found in the various King-
doms (Animal, Veget., + Mineral), forms
the greater mass of the Earth - the
air. is the great supporter of com-
bustion. Is ^(a) transparent - color-
less. ^(uncoverable gas) odorless. Hydrogen H.
(placed with the metals)

7

H

Eu

is as unobscure as O₂ - a colorless &c gas. On acct of its abundant occurrence & the importance of its Compds. next to O₂, is a gaseous metal - if condensed probably like Hg. Will not support Ord. Combust. like O₂ - but burns with a blue flame

Lecture IInd

Cl. Br. I. Fl. come next in Order - not free in nature. all in Compds. Cl - is a yellow-green gas, condensible - name from Chloros, green; suffocating odor, & poisonous, attacking animal mat. Have some around.

Cl-

green gas, condensible - name from Chloros, green; suffocating odor, & poisonous, attacking animal mat. Have some around. (Cl HO), Property of bleaching vegetable col. matters.

Bromine,

Analogous in its Compds & Chem. Charac. to Cl. found

where Cl is found, in the same combinations, but not so abundantly. In physical props - it is different - a brown red liquid volatilizing at Ord. temps - to a Br similar colored gas. (Cl + Br both give colored gases). Bleaches; name from Bromos. Poisonous.

Iodine.

Occurs similarly - but still more sparingly than Br. As a brown black metallic lustrous solid - volatilizing at ord. temps - to a beautiful violet colored gas & note, ~~from~~ I whence the name, Comp's & Chemical Charac, similar to Cl & Br.

Fluorine

More sparingly than Cl. less than Br, Fl ord. Resembles O in its Comp's - it is most abundant in Ca Fl.

9.

S, Se + Te, great resemblance
to one another, S so common
that no mention is needed.

Selenium. - very anal. to
S, much more than Br to Cl re.
diff. in Phys. props.: very rare

in nature - but present in
traces in Sulphur Compds.

Selen. is a ^{salib.} comb. of metallic
lustre - vaporizes easily like S.

Test - its Characteristic smell.

Tellur. - More rare than Se
Hungary - California (in Te + tell Te)

Te Physical Prop. of metal, lustrous.

Vaporizes easily - burns with
a green flame, without the
acc. smell like Se.

Nitrogen Group. Comprising
N, Ph, As, Sb, is the next.

Nitrogen - a constituent of the
atmosphere - an essential

colorless + c gas - seldom en-
ters into Compd - Character-
sluggish - In organic bodies N.
mainly - in NH_3 important.
Small quantities of $\text{NO} + \text{NO}_2$ -
in atmosphere - Manufactured
from air, No supporter of
Combustion, Extinguishes Ex
a flame instantly, & very in-
ert - has little tendency to en-
ter into combinations,

Phosphorous.

A waxy white solid - semi-trans-
parent, easily vaporized
not free in nature - abund- P
ant in nature + in bones as
 3CaOPO_5 , Organic life depen-
dent on it in this form,
Plants + animals, Has an
exceeding affinity for Oxygen, Ex
Combines with it slowly at 80° .

Temp., with increased temp. -
or friction - combines with
great light & heat

Arsenic.

Tolerably abundant, in many

Ex Pres - with m + Cl, as $AsCl_5$
+ $AsCl_3$. Found free in nature.

Possesses metallic lustre,

As Burns with a blue flame to
 $AsCl_3$. The vapor has a
characteristic smell etc \rightarrow
garlic. All compounds are
highly poisonous.

Antimony.

Lb. Similar in occurrence to
Arsenic; but less abund.
C, Bo, Si, Zr, form the next
group. Sb. is too well
C known to need description

Bo Bo - only combined in
nature as Bo - are important

Found in many mineral waters as BoO_3 salts. In Tibet, it is abundant.

Borax - $\text{NaO } 2\text{BoO}_3 + 10\text{HO}$, crystal.

Silicium.

It is only found combined in nature - & exclusively as SiO_2 Sand - Quartz &c - & in combination as Silicates, of KO , NaO , CaO , Al_2O_3 &c, forming Mountain masses, & $\frac{3}{4}$ of the crust of the earth. The element resembles C. or Bo, combines with O, but not so readily.

Zirconium.

Very rare, as Zircon (Hyacinth) found in many places sparingly - In Norway - Zircon Syent - resembles C. & Si. It has furnished the metalloid, no sharp line of demarcation exists - but gradually enters

into one-another. Metals

Have great resemblance to each other in Physical properties. + Chemical.

alkalis 1st group Sodium } General properties described.
 2nd } Potassium
 { Cesium } Difficultly separated from each other.
 { Rubidium

Exp → Decomposition of H₂O by NaOH.
 → Show the flames + mode of distinguishing them.

group 3rd { Magnesium } Not so intense, and their affinities
 { Lithium } but still alkaline in character.

Li very rare but widely spread. Lepidolite, Spodumene,

Mg - much used as metal

Exp Properties → burns at high temp - with brilliant white flame,

4th group Ca, Ba, Sr } brilliant yellow metals

with great affinities for Oxygen
Occurrence, uses &c,

Erbium } Rare, only found 5th group
Yttrium } in one or 2 Minerals.

Cer }
Lanthan } Ditto - in Norway, 6th group.
Didym } Separation difficult.

Thorium } Al is exceedingly
Aluminum } abundant, but 7th group
Beryllium } nowhere free in

nature - Much used in metal-
lic state - Silver white - Sp. grav.

Small - a clear metallic ring Al
Very stable - Jewelry &c,

The other Metals Fe, Cu, Au -
Ag, Pb, Hg - are too well known
to need mention,

Detailed description will
be made at the appropri-
ate places.

Lecture 3.rd

The other metals described.

In examining substances, we find always 2 or 3 or more of these substances in them.

The question now arises, Are these the veritable Elements?

i.e. have we determinate proofs of their elementary nature?

There is no proof that such is the case - Except of a negative nature - Explain,

Not positive - instance Sir H. Davy's discov. of K, Na &c, so that we can only say these bodies - have thus far resisted ~~all~~ the combined efforts of Chemical reagents - of Heat + Electricity - to decompose them into 2 or more - & in that sense are Elementary

Are these all the Elements?

No proof that such is the Case.

With a advance in Science new

Elements have been discovered

Many very rare - Spectral Analysis - 4 new elements discovered by means of it. } Are there all the Elements sub?

Ches, &c, on the Earth's, surface

or in the waters are all the

Elements? Our Knowledge of

the Earth & its contents - extends

only a few feet below its sur-

face -, & only one fourth of that

is open to our researches, -

for H₂O covers $\frac{3}{4}$ of the Globe

& of what is below the ocean

we can only Conjecture - of the $\frac{1}{4}$

that is left is - at least $\frac{1}{3}$, is

inaccessible to us; by reason

of Unscaleable Mountains - of
 deserts - or of Ice & a frigid
 Climate - The deepest mines
 Compared with the real extent
 of the Earth's diameter - are but
 pricks upon its surface; all
 the rest of the great world lies
 beyond our direct investi-
 gation; But - even with such
Little apparently poor encouragement
 we are able to say with al-
 most positive certainty - that
 what exists within the bowels
 of the Earth exists likewise on
 its surface. For! ————— are
 have three great divisions;
 or parts to the Earth - Air - Water -
 & Solid Earth.

Air - Composed of N + O - mainly,
 CO_2 NH_3 + NO_2 slightly - these
 constituents occur every

where - we may make an analysis
 wherever we please - we
 find these + only these consti-
 tuents - Water! - chiefly H+O,
 likewise Cl, S, Br, Fl. K. Na. Ca
 Ba. Sr. Mg. Al. Co. Pb. Li. Mn. &c.
 Here, too, we find the same con-
 stituents, + need only make one
Analysis, to give us the com-
 position of the ocean anywhere,
 Solid Earth - Here, too, we Same
 find a certain regularity of dis-
 tribution, though the compli-
 cations + differences are greater
 than with air + water - The
 Earth is a flattened globe -
 So the planets - Sun &c, the Earth
 (+ planets) revolves around the Sun,
 (Direction same with all) - We know
 that only a fluid body will
 take on a globular form.

Hence, the conclusion lies at hand that the Earth has once been fluid - It could not have been dissolved - for the water is much too trifling in quantity to accomplish that - hence, the solid parts of the Earth must have been in a state of fusion. This is most probable. Explains most thoroughly the globular form & note Laplace's theory, its probability so great, that it amounts to as much certainty as that every organic being must die. The temper. increases as we dig into the Earth - about 1°C for each foot.

Springs are often boiling hot when coming from depths of the Earth. Volcanic action in all parts of the Earth - from the Equator to the poles testifies to the high

Temp. of the Earth's interior - the pouring out of liquid rock, over square miles of surface, is a direct proof of the fact, that Lavas Come from Considerable depths is indicated by the generally attendant Earthquakes. { Volcanic Action

There are great masses of rock, which, from their position & mineral characters indicate with certainty that they were originally formed by volcanic ejections -



side the proper lavas - Plutonic Rocks These are constantly subject to change - by action of air & moisture & mineral springs - change - both chemical & physical. For soluble parts are carried away - others are mechanically disintegrated &c. All deposits of the

ly Rivers or currents of the sea,
are formed by this action - i.e.,
mechanical grinding of previously
existing rocks, these last we

Neptun- { Call to contradistinguish them from
me { the Plutonic - Neptunian Rocks
Rocks { they comprise the mass of those
exposed to our view. Then there
exist changed rocks - (i.e., altered

Metamor { since their deposition) we call
phic { these Metamorphic Rocks.
Rocks { In all these however we meet
with nearly the same constituents
in common - & all known Elements
(no new ones); (Every stone -
or Rock may contain every element

Note { in its composition - but most of
them in such infinitely small
quantities, that it is impossi-
ble to detect them - by any
yet devised mode of analyses

this probability rests upon the assumption of the former fluidity of the Earth? An analysis of Plutonic rocks of all ages show slight changes - the old ones being changed, but of present (note) lava the compos. is most identical & there are other proofs that we have upon the Earth's surface all the Elements in its interior.

It is an unvariable rule (eq. with Hor. Be.) that upon solidifying a body contracts & grows sp. heavier, the tendency would be to form a solid nucleus - the surface being last to solidify - The immense quantity of heat, still within the depths - being capable only of slow radiation; would cause extensive & violent chemical action beneath the surface, Waters of the Sea - containing salts in

Solution - would sink far down
 through fissures & cavities, or
 infiltrate to great depths - & would
 act as they yet do - this violent
 action - (& Chem. action per se
is a cause of Heat) new com-
 binations wd be formed &
 gases evolved (H_2O vapor) - which
 by their Expansion would exert
 such sundering force - that
 local upheavals & fissures wd
 be formed - through which wd
 be forced the rocks melted
 by the intensity of Chem. comb, &
 metals in fusion. Etc, Etc.
 The analyses of these rocks of
 Plutonic origin - form now constant-
 ly - have given us no new elem-
 ents - on the contrary they show
 a surprising uniformity of
 composition.

Lecture 4th

The conditions of the Earth resembled that of the present sea & of the atmosphere -

If we imagine the Ocean to freeze - we should have the same conditions as are given in the solidifying of the earth -

First - NaCl would crystallize out then other salts according - to their solubility - So the various substances in the fluid globe would separate one after another - The deeper we go - the more different the compositions become. The lavas from volcanoes, show a slightly different composition. In Iceland volcanoes, & others we find one composition - In other volcanic chains we find - Lavas of a constant but slightly different in composition.

Others again, show a mean - or middle composition between the two extremes. ~~Which~~
If the volcanic chains are bound

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together by subterranean channels we know not, but the constancy & appearance - of lavas from the most different volcanoes - indicate that such is the case - The middle lavas - show a great variety of composition between the two extremes - {Pyroscopic? lavas. Trachytic?} Without the lavas - we find a great regularity in their composition - which corresponds with the Trachitic lavas. Trappean & Basaltic rocks.

Analys.
of
lavas.

These analyses give us a clue - to the substances that compose the mass of the earth at great depths - We ought however to find all the elements in these rocks - but we have been unable - to detect all - If then we have found a method of detecting an infinitely small quantity of substance, we may find them.

The rare metals & substances - we find that nature has given us to know in another way - namely By collecting them by Chemical

action, which has separated them²⁴,
here & there in considerable mass -
we call them veins, &c. &c.

Mineral
Veins

Druzen &c. &c. In these places
we find the greatest part of those
extremely rare bodies, mixed &
accompanied with more com-
mon substances.

Is the mass of our planets & the
sun - of the stars - or nebulae -
the same elements as the earth?

The spectral analysis has shown
that generally those bodies of the
same elements - & of no others as
those we find upon the earth -

Sugar - Meteorite - stones & bodies
that fall upon the earth - Meteorites
from the depths of space -

Give us, by the most careful
chemical analyses - the same
elements - as ours - & no new
ones. All of them - however
various the time or place of their
fall - show a great similarity
of composition - mostly composed
of - Fe - Co - Ni. The cause of their
explosion - is the repulsive force

Compos. of.

of heat - evolved as an equivalent for the loss of its velocity?

Princip.
+ applica.
of
Spectral
Analysis

The planets giving us only light reflected from sun - we can not tell directly of their composition.

The Sun being a luminous body (which fact alone is an evidence of the great temperature of the central orb), sends us light from its various substances, all in an exceedingly heated condition; & we have learned that, the vapors of different elements - have the power ² of emitting certain kind of light, so that by examining that light by means of the appropriate instruments we have a means, certain and of the

It shows
no
new
Elements
in
Celestial
Bodies

extremest delicacy of knowing what substances are present or absent from a body even as distant as the sun. - The light from that body when properly analyzed, shows us no new elements - but - show - what might be expected - that - its mass is composed chiefly of the same components as that of the numerous meteorites; which has been already mentioned -

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We have carried this method of analysis even to the fixed stars - the distances of the nearest of which - are beyond calculation or imagination and ~~and~~ the results have shown - the same elements that meet us in & upon the Earth - are found there -

Even the nebulae - which in some parts of the heavens - stretch themselves ~~for~~ to the extent of more than a degree of arc - & whose distances defy even calculation - have been analyzed - & no new element has been detected: But - what is a natural expectation - we find that some elements - which are present only in the most meagre quantities upon our globe - compose in some of the celestial bodies the mass of their bulk - One fixed star for example has shown that Tellurium - one of the rarest elements upon the Earth - is present in its composition in great quantities - In another Cerium & Lanthanum & Didymium) are ^{as} abundant as they are extremely rare here.

The nebulae are all (those that have been examined) composed of two gases - present in abundances on our globe - namely Hydrogen & Nitrogen

Some Elements abundant in stars - which are rare on the Earth

H & N in Nebulae

no also. The metals & metalloids gradually
 lose difference & melt into one another - & there is
 no sharp line of demarcation
 between them. The metalloids
 possess a general class of proper-
 ties that the metals only pos-
 sess in very small degree -
 Namely - of Physical Properties
 Durchsichtigkeit - transparency
 comes into play much oftener
 than with metals -

Physical
 Properties
 of
 Metalloids
 Comp.
 to
Metals

Cl. Br. I. O. H. S. Se. N. P. &c
 are all transparent. We must
 take the solid bodies - in thin
 plates - & not in masses - for
 even glass the most transparent
 of solids will not transmit light
 when only thick enough. Water
 ditto. The metals are only

Exper.

transparent in infinitely small
 quantities - infinitely thin plates -
 Gold - z. b. Some Metalloids are
 in untransparent & transparent -
 at in different physical condi-
 tions - Carbon - z. b. as Charcoal -
 & Diamond.

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We are only able to make leaves
of one metal in leaves thin
enough to be transparent -
Gold. Exper

2nd general property - The metalloids
are generally bad conductors of
Heat - Carbon - can be held in the
hand - without being heated - Metals
on the contrary - are great conduc-
tors - Silver - e.g. It is however
like the first - only a relative
& no positive difference. Ditto

3rd The metalloids are bad conduc-
tors of Electricity. This again is
only a relative difference - Tellu-
rium & Selenium form a
transition point between the
metals (or good conductors)
& the metalloids. Here - one &
the same body - in some conditions
are conductors & non conductors.

Experiment showing - the Exper.
relative conductivity of some
Metals & metalloids.

Show this conductivity by holding
metals & metalloids between the

29 connection of the stream.

When we bring the elements ~~into~~
into contact with each other - elec-
tricity ~~the~~ is generated & indeed
electricity of different kinds.
one Positive & the other negative.

(Sb. & a)
- +

The metalloids generally when
brought into contact with the
metals - generally - take on, or
become - negatively electrical
while the metals - become
Electro positive. This gives us
the Elemental Electrical row.

Electro-
cal Char-
acter - the
distinction
between
Metals &
Metalloids

The Electro Character is also
nothing positive, but the row only
indicates that the body below the
one above is more electro positive
but with the body above it - elec-
tro negative.

The farther apart - the elements
stand in the row. the greater
the Chemical affinity exists
between them.

When a Chemical Compound
has been formed we find - that
by leading an electrical stream

through the compound - these ³⁰ elements of the comp'd - are Electric.
given off at determinate Decomp.
poles - & indeed - the electropos-
itive Element - at the Electric-
ally negative pole, & the Electro-
negative Element - at the positive
pole. The reason is that the
opposite Electricities attract one an-
other -

← $\text{Cu}^+ \text{O}^-$ ← Experiment with CuO SO_3 . Exper.

& show that Cu is given off at negative &
O at positive pole.

These Electrical properties are - the
reason of dividing the Metals &
Metalloids into their groups.

The Erfahrung shows that
Chemical Compounds show Elec-
trical properties positive & nega-
tive - so that the Battery gives
us no positive proof of the pres-
ence of Elements - by Electrical
decomposition.

We can combine - the Metalloids Exper.
& metals with oxygen - & the
bodies thus gotten show electrical

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Electric.
Difference
Not an
Absolute
one

entirely different bodies -
as we have formerly remarked
there being no absolute difference
between Elements & Compounds -
these Compd bodies should behave
exactly like elements, & these
two classes just mentioned -
should possess the same affinity
for each other, the the metals
for O - or as the metalloids for
Oxygen. & this is truly the

Exper.

case. (Ba + O) (Arsenic + Saurstoff)
& these two bodies both compounds
united with each other with the
evolution of light & heat -

But then we would have three ele-
ments variously disposed - how
they are disposed or positioned we
know not, but can only theorize -

Electric
Charac.
of
Terminaries

Concerning these Compound bodies
they show the ^{great} same similarity
to the simple Elements. In
reference to Electrical properties
the similarity is perfect & we
might make a Electrical
row - of compounds. if the difficult.

ty was not heightened by the
immense number of these
bodies that we can bring about.

If also - we lead a stream of Electricity
through solutions of these compounds
we find that just like Binaries
the two compound bodies are separa-
ted at different poles - showing
a difference of electrical properties.

The bodies compounded like Acid +
Binaries - of the metalloids Base
we call - Acids - + those
Binary compounds of the Metals -
generally bases -

These again - acids + bases -
are not distinct + determinate -
bodies - that is - the line of demar-
cation is not so sharp, as one might
suppose - some bodies - (just as they
may with ^{one substance} ~~another~~, be elect^{ro} positive
+ with another be elect^{ro} negative) -

may with one compound body -
play the part of a base - +
with another - the part of an
acid.

Lecture 6.
Tabelle.

Seidepunkt des Wassers.

bei. 1.	Atmosphärische Druck	100° C.
" 2.	"	121.4°
" 4	"	145.4°
" 10	"	181.6°
" 20	"	214°
" 50	"	265.9°

Acid +
Base
Properties
of

The acids - or combinations of metals with O - have generally an acid or sour taste - Those of the Metals - with Oxygen are soapy or alkaline taste -

The Metalloid combinations have certain properties when brought into contact with vegetable colors.

Tests for

The bases have - an entirely different property - so that we have an infallible + delicate test for the nature of a combination under examination -

The colors generally used - are mostly - Litmus - Red Cabbage - or Turmeric - & use them in

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such a way that, we dip
paper strips in solutions of these
various coloring matters, & then
test with the paper thus prepared.
The Acid or Base to be tested must
of course be in a solution.

Litmus - most generally used - acids
show a red color - Base a Blue one

Red Cabbage - (a blue solution) - Ditto

Acids bring forth - a red color

Bases " " " green color.

acid & base when they have been
united with one another - lose the
distinctive property of affecting reg-
ular colors - & act perfectly neu-
tral toward - such solutions.

Acid & base behave toward the battery
in precisely the same in their combina-
tions - as simple compounds.

The Acid - given off at the positive
pole & the Base at the negative pole.

(Show the decomposition by Electric-
cal stream - of Na_2SO_4 & show Exper.

the separation of acid & base
at the 2 poles & show presence
of either by Red Cabbage.

Characteristic Lecture Experiment



Physical Condition of the Elements

The elements are of all physical conditions - gases - liquids + solids. Is this property of being gas - liquid or solid something inherent in the body or something changeable? Experience has shown that we can bring back all the elements - into each of the three physical conditions - Solid, liquid - + gas -

The appearances that indicate the transition into these various conditions are important to the chemist.

Exper. A piece of sulphur by heating to a certain number of Degrees - (under like conditions) $114^{\circ}30'$ is converted into a liquid - by this means, by this performance - a certain amount of heat - during the process of smelting - is rendered latent - the sulphur becomes no hotter. This point at which a solid body turns into a liquid is called the Melting point. If we continue to heat - we will arrive at a temperature at which the liquid will be converted into a gas - During the

operation of Condensation we must ^{36.} Ditto
give heat to continue the
operation - for, like in the previous
case - heat is used up - in the
process of condensation. This point -
is always the same for the same
~~temperature~~ + pressure. & is called
the boiling point - In the contrary
process - the passage Z.B. of a gas to
a liquid or a liquid to a solid - the
heat that had been used up, is given
off.

These different Boiling points + Melting
points - are dependent

1st Upon the Nature of the body

2nd " " Atmospheric pressure.

~~3rd~~ " " By increasing the pressure we raise
the temperature of melting + boiling.

That is, the Boiling or Melting point
is directly proportional to the
Pressure. If we had a pressure
upon the earth 50 times that of
our present atmosphere - the boil-
ing points of various substances
would be entirely different - H_2O for
example - $265^{\circ}9' C$ - See Table
at beginning of lecture.

It is of great importance to deter-

37
mine accurately the Boiling & melting points of many important bodies - The process explained: Put the body in a tube & allow it after making lukewarm to solidify around a thermometer - & heat gradually till the thermometer becomes constant. For small quantities of substances the following is a good method -



Exp. Bring the substance in a liquid state into a sealed tube & seal it at both ends. fasten to its side a thermometer & bring the body in hot & cold water of the body melts in hot water -

Note

Note the temperature - & mix with colder water - if too cold - mix with hotter - until the point is brought within a tenth of a degree -

The stirring of the body is always well in determining the melting & boiling point - because when the liquid is left perfectly at rest - there is always more or less - according to the nature of the body (fluid & vessel) substances - attraction between the sides of the vessel & the particles of the fluid. This attraction - acts as a resistance - to the

Deter-
mination
of Boiling
& melting
Point

Change in the physical condition ²⁴ Same
of the fluid, which requires the
addition of so much more heat
to accomplish the work, of conver-
ting, the liquid to a gas. By stirring
the fluid, this attraction is overcome,
because a particle is not at one place
long enough ~~at one~~ to exercise its
influence in this species of surface
or Capillary attraction.

Examples of its influence are abun-
dant & failures, sometimes very
great may be made by disregarding, or Influence
overlooking the necessary precautions on
to prevent the action of the Capillary
force - in influencing the boiling Boiling
points of liquids & vice versa, the solidification
Water when left perfectly quiet in
a glass vessel with smooth sides,
can be heated - as high as to 120°C
(20° above its normal boiling point)
without being converted by boiling into
a gas. ^{Supersaturated}
A solution of NaO SO_3 (Saurer's Salt),
covered with a small quantity of Oil -
to keep the surface from agitation,
will still retain its liquid form - at
an exceedingly low temperature - far
below that of its solidification, if Copper
however, a crystal of NaO SO_3 , or an
angular piece of glass - or of any other
substance - be brought into the solu-

27
Ditto tion - or if the solution be stirred with a glass rod - or if the particles are in any way set in motion - so as to lessen the attraction of Capillary - the whole mass solidifies with great rapidity - and the temperature rises at once to that of the Condensation of the salt - So quickly does this take place that the bottom of the vessel in which the crystallization^{is} taking place becomes appreciably ~~hotter~~ hot.

Exp These facts explain also - why a handful of sand - thrown into a vessel of hot water - gives rise to a sudden evolution of gas (water vapor) - & causes evaporation to proceed more rapidly & more regularly. The angular points of the sand - possess little attracting power - & allow the ready escape of each bubble of vapor formed upon them - while the great attraction of the smooth sides of the glass act in a directly contrary way.

Exp In the laboratory - when we wish boiling to proceed regularly & not fitfully & with violence. as it otherwise will do more or less - to the danger of the glass vessel - we place a few angular stones in the bottom of the vessel, which answer the purpose of lessening this attraction very well.

Lecture 7th

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Boiling point - dependent upon Boiling
1st - Nature of the body Point
2nd Pressure.

Small alterations in pressure -
such as occur upon the earth -
at variable levels. alter very ma-
terially the Koch - point.

There are several Vorsichtsmass-
regeln to be observed.

The nature of the containing -
vessel alters surprisingly the Boil-
ing point. We can make 140 Boil
after it has ceased - by throwing in Exp
the vessel - Metal pieces.

To avoid mistakes we must not
~~be~~ put the thermometer in
the fluid itself - but lower it -
& finally a point will come at which
the temperature will be constant -
that is the boiling point.

Can every body exist in the three
physical conditions? We answer this
question in the affirmative - We have
been as yet unable to reduce some
of the Elements to a liquid or a
gas solid state - Hydrogen + Oxygen

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+ Nitrogen. But ^{with} many other elements. Chlorine &c. we have succeeded. The Reason is that we have not the means at our disposal to bring about such exceedingly low temperatures, or such immense pressures - as are necessary, to change these gases - to liquids or to solids. With compound bodies - however do not all + can not all exist in each of these conditions - for in converting a liquid, for example, into a gas - we may have arrived at a temperature at which the chemical affinity of the Elements composing it - will be overcome.

There are some bodies which - appear, to leap over some of the physical conditions.

Sublimation

Sulphur &c. pass - from the condition of a solid to a gas - skipping from over the middle condition of a liquid.

Explanation of sublimation - With some bodies - the melting point + boiling point lie very close together, + with some Elements (As. S) - it lies (that is the boiling point) - lies below the melting point - so that the body - instead of being converted from a solid to a liquid - passes at once over into the gaseous form.

112.
By increasing the pressure that
bears upon the body we may
change its physical condition from
a solid to a liquid - or from liquid to
a gas - By decreasing the pressure,
on a solid body we may bring about
the contrary & make it liquid. Physical
from a liquid by the same means Conditions
from a liquid to a gas.

A body in a chemical compound
may have either of the three physical
conditions, apart from its definite
laws of boiling & melting.

$\text{Na}_2\text{SO}_3 \cdot x\text{H}_2\text{O}$ = at ordinary temper-
atures the H_2O is contained in
this salt as a solid - If we bring
a body to this which has the prop-
erty of seizing upon the H_2O - &
if the seizing body is liquid - or
has the property of being liquid, at
ordinary temperature - the water
of combination - is seized upon, & con-
verted at once from a solid to a
liquid form - but in this conversion Exp
the heat formerly necessary, must be
extracted from the bodies involved -
& hence an immense degree of cold produced.

Freezing
Mixtures
Expt'd

Ex

Coal mixtures are explained upon the same principles.

$\text{NaO SO}_3 \times \text{H}_2\text{O}$ mixed with HCl - for example. The HCl seizes upon the H_2O of the NaOSO_3 & converts it from its solid state in the salt into a liquid with which it combines - By so doing however - the H_2O requires heat - to exist as a liquid, & that heat is extracted from the HCl & the NaOSO_3 producing great cold.

Bodies which assume the solid state rapidly. as by freezing - they take on the form of the containing vessel, but show no distinctive internal form, no even lines no angles - no lines of cleavage - such bodies are called Amorphous.

But when a body passes slowly from the liquid to the solid state - a surprising fact shows itself -

Crystallography

namely - that the solidifying is brought about by the formation of numberless regular figures - forms & bounded by planes & angles - & what is of more importance - that for the same substance - the same form always ^(shows) itself - that is - the solidification takes place in obedience to fixed molecular laws, which

Illustrated

every body obeys - with few excep-⁴⁴
tions - These forms stand in the Ditto
most intimate relations with the
chemical & physical properties
of the bodies presenting them.
It stands (the Crystalline form) in
connection with the chemical prop-
erties of the body - in as much as - with
the same composition chemically - always
the same crystal form is presented.
NaCl, for example, when it crystal-
lizes always does so, in the form of the
Hexahedron (or Cube) - or if not in this
identical form - in one which is a
combination of that form, with another
- which stands in intimate relation with
it. $K_2SO_4, Al_2O_3, 3SO_3 + 24aq$ - always crystal-
lizes - in Octahedral forms - or in combina-
tions of the Octahedron.

The Crystal form - stands in near rela-
tion to the physical properties of the crys-
tallizing substance. in as much as, certain
unmistakable physical peculiarities -
always show themselves with the crystal
of each substance - A certain glance -
a fixed - hardness - distinct planes
of cleavage (when these exist) etc -
ect. With Galena - for example -
A substance which Crystallizes in

Ditto

the first or regular system - cleavage planes are always found parallel to the surfaces of the cube.

Mica - shows cleavage planes parallel to the basic surfaces O.P. &c.

But aside from these distinguishing properties - the science of crystallography has in late years been rendered of far more importance to the chemist by the discovery of Isomorphism.

A discovery of this Century by Mitscherlich - which shows that there is yet a more intimate connection of these molecular forces - & the chemical nature of the body.

Isomorphism shows that bodies which have a similar chemical nature, that have, namely - similar chemical composition - though in reality composed of different Elements - that these bodies - crys-

tallize in similar - & very often in precisely identical forms. Z. B.

$2 \text{NaSO}_3 + 7 \text{H}_2\text{O}$	} all the salts here mentioned crystallize in the Rhombic system - in exceedingly similar forms, with almost the same angles of inclination of the surfaces.
$\text{NiO SO}_3 + 7 \text{H}_2\text{O}$	
$\text{MgO SO}_3 + 7 \text{H}_2\text{O}$	
$\text{MgO SeO}_3 + 7 \text{H}_2\text{O}$	
$\text{MgO CrO}_3 + 7 \text{H}_2\text{O}$	
tc &c	

Lecture 8thCrystals

Crystallography Continued. The Principles of Classification by Systems mentioned. Laws of Combinations. The law of Symmetry. Whatever surface, corner &c - that shows itself upon one surface - corner or edge, must likewise show itself upon every other corner, surface, or edge similarly placed with reference to the axes. The size of the combining surfaces is an irrelevant matter, the place & mode of their occurrence is an absolute one, as also is the angles which the combining surfaces make with the chief figure, namely with the surfaces of it. The angle of the surfaces of simple figures is also constant - $\bar{O} = 109^{\circ}.28' .00 = 120^{\circ}$
 $\frac{O}{2} = 70^{\circ}32' \text{ &c \&c}$; so that a glance at the positions of the combining surfaces, tell us the system - while in all doubtful cases, a measurement of the combining angles - will give us a clue to the individual combination before us.

47.

Illustra.

When combinations of various surfaces are brought about, by those that do not cut the axes in the normal distance of the ground form - these surfaces always cut the axes in less or greater distances - if we suppose the axes to be lengthened till the surfaces meet them - & this distance be it longer or shorter than that of the main form, is always some simple multiple of the apical relation of the main form.



$$\tan \beta = \frac{CB'}{CA}$$

$$\tan \alpha = \frac{CB^2}{CA}$$

$$\tan n = \frac{1.2.3 CB}{CA}$$

Further physical properties.

With many solid bodies there are many physical properties very different among themselves.

Hardness. is something which bodies possess in very different degrees. Hardness is something

entirely different from Specific ^{48.}
Gravity - & it is expressed by the
resistance which the particles of any
chosen body - offer to being scratch-
ed by another. The harder body Hardness
scratches the softer. In Miner-
alogy this property is of importance.
to the chemist of very little.

Malleability } Molecular properties
Ductility } of the metals generally
& of little importance in Chemistry.

The property of many bodies (in Elasticity
a solid form) & also expressed by
tension in gases - to resume their
former condition when the parti-
cles have been displaced from
their original condition by mechan-
ical force is called Elasticity.

Rubber - Ivory - are bodies pos-
sessing this property in a very
high degree. Brittleness - is the
contrary of Elasticity. Glass is
an example of such a body -
When cooled rapidly - it is so brit-
tle that it cracks & falls to pieces
of its own accord - hence glass
vessels made for use - must al-

ways he cooled with extreme slowness. This is the process of Annealing. A frequent example of this property in an extreme degree is illustrated by drops of solid glass - which have been cooled suddenly by dropping in cold water - by breaking off the smallest end - the whole mass bursts into powder - called Dutch Drops.

Brittleness

Lecture 9th

50

thick glass vessels unannealed may be broken by throwing into them - small angular pieces of sand - or stone -

Expansion is a property of which we make no special use - in Chemistry - Heat is the exciting cause of the display of Expansion. Depends upon →

Expansion

- 1st The Nature of the Body
- 2nd The previous Condition of Do.
- 3rd The temperature.

Glass & Platinum are equally expansible - for equal degrees of Temperature Changes. By virtue of this valuable coincidence we are enabled to smelt glass & platinum together - in many Cases - where apparatus of value - require something of the kind - With Copper & other metals - It is impossible to smelt them with glass - for upon cooling - one or the other would contract more quickly & the result would be - either to crack the glass, or to loosen the connection between them.

Specific Gravity

The Sp. Gr. of bodies is, on the contrary of vast importance to the Chemist. who understands under this name the relative weights of the various bodies compared to some common standard as a unit of weight. (H_2O for Solids + liquids + air for gases)

The Specif. Grav. of bodies is something constant, other things being equal. So that, at times, it may serve as a means of detecting & separating the various substances.

The methods are the following.

Compare the weight of a certain volume of any substance with that of an equal volume of H_2O . Divide the first by the last + the problem is satisfied.

Pyknometer

The Specific Gravity bottle - is a small flask furnished with a small perforated stopper, whose perforation consists of a Capillary tube - The Bottle is filled with H_2O + carefully weighed - at a certain temperature. Call this weight = g . The substance whose Sp. Gr. is to be determined is now weighed

for itself: call this weight a 52.
 It is then brought into the Bottle. Do.
 filled carefully with Distilled H_2O
 freshly boiled - the stopper thrust in
 carefully wiped - & allowed to attain
 to the same temperature as that
 of the first weighing. call this = G .
 We then have for the spec. grav.
 of the substance the following -

$$\begin{cases} g + a - w = G. \\ w = g + a - G \end{cases}$$

Determin
 ation
 of
Sp. Gr.

Where w equals the weight of
 the water displaced. If we call
 $w = 1$ we have for sp. Gr -

$$\frac{w}{w} : \frac{a}{w} :: 1 : x \quad \{ x = \text{sp. Gr.}$$



The precautions to be used are as
 follows. Temperature of all the
 weighings must be the same.
 The water used must be distilled
 & freshly boiled to remove air -
 & when brought upon the subst-
 ance it must be placed on the
 air pump & the air surrounding
 the solid pumped off.

Do of
Liquids.

To determine the sp. gr. of Liquids we have only to weigh a Bottle of the Liquid - (with the same precautions as before) + then a bottle of the H₂O. divide the weight of the former with that of the latter. + the problem is finished.

Do of
Gases

With all Gases. the greatest dependence + the most intimate relation - shows itself between its chemical nature + specific gravity. With Solid bodies the pressure exerted upon its surface does not affect its arrangement of particles in the interior - with gases a pressure in one point is communicated to all. While also with liquids + solids, expansion + contraction is small in amount and irregular in character, with Gases. it follows an invariable + regular law. The same Law too regulates the expansion of all gases, when far from their Condensature points. Discovered by Gay Lussac + called from him Lussac's Law of Expans. of Gases.

Do

35

Condensable gases. It is only with those gases that are condensable that this law suffers variation.

This small factor it will be seen too is good for all variations of temperature.

If we should measure the volume of a gas, to day, for example - to -

Morrow - or, even in a few hours - another observation would give a different volume. For temperature is seldom constant for hours at a time.

In all these measurements therefore we would be obliged to surround the gas with a freezing mixture of melting ice, so that the temperature should be a constant one, but as, in many cases this would be inconvenient & sometimes impossible; we have however a much simpler method. namely - We have seen that the increase or decrease in the volume of a gas is a constant factor - for all temperatures. We have only then to measure the volume

To
Measure
the
Vol. of
Gases

at the temperature which may ⁵⁶ happen to rule at the time, & then Do.
by a simple use of this factor, reduce
this volume, to that one, which it
would have at any other temper-
ature assumed as a standard.

For example. we have observed
a volume V at a given temper-
ature - & wish to reduce this
volume V - to a normal one, at
0°C. We should proceed as follows,

$$\text{Observed volume} = 1 + (0.00366 \times t) = V$$

$$\text{Volume at } 0^\circ\text{C.} = 1 = V'$$

$$\text{Temperature observed} = t$$

Then.

$$1 + (0.00366 \times t) : 1 :: V : V' \text{ or}$$

$$V' = \frac{V}{1 + (0.00366 \times t)} \quad (1)$$

By applying this formula to dif-
ferent volumes we are enabled
to a standard volume for a
standard temperature, without
the necessity of first obtaining
the temperature - then performing
the measurement.

Lecture 10th

Do

If we wish to reduce one volume to another at any given temperature not necessarily 0°C . we need only the following alteration in formula (1).

$$(1 + (0.00366 \times t)) : 1 + (0.00366 \times t_1) : v : v'$$

$$\text{Or } v' = \frac{v \times 1 + (0.00366 \times t_1)}{1 + (0.00366 \times t)} \quad (2)$$

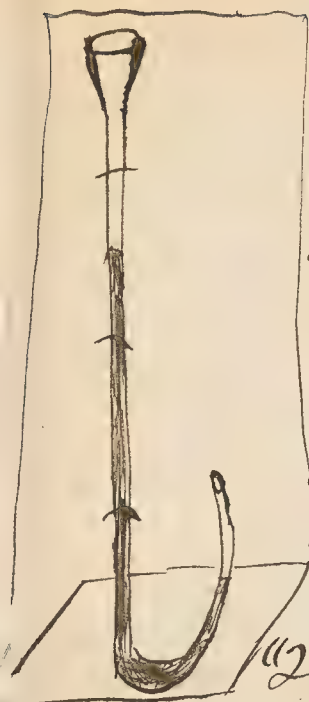
Where however the value of $1 + (0.00366 \times t_1)$ becomes Unity, as it would were the value of v' understood to refer to 0°C . then formula (2) would become formula (1) or.

$$v' = \frac{v}{1 + (0.00366 \times t)} \quad (1)$$

Where the values are the same as on page 56.

Do
with
Liquids
+
Solids

Gases show with pressure a remarkable law of regularity - as with temperatures. While, as has been mentioned - solids & liquids show no regularity with regard to change of volume by pressure, Gases show a remarkable one. of utmost importance in Chemical investigations.



Show the law of pressure
by an arrangement like Expt
the following - show that
the expression of that law
is - The volume of a gas
decreases with the pressure
& decreases by a certain reg-
ular law. Namely \rightarrow

"The volume of a gas is in-
versely proportional to the pressure
to which it is subjected". Called Marriott's Law
from its discoverer, Marriott's Law.
When far from their Condensation
points it is good for all gases.

V = vol. at a given pressure

V' = vol " new "

P = Pressure for Volume V

P' = " " " "

then.

$$V : V' :: P' : P$$

$$\text{or } V' = \frac{PV}{P'} \quad (2)$$

Which expresses the relation bet-
ween volume & pressure - with
all gases without exception -
in the above mentioned restriction.

59.

Pressure & Volume of Gases

When therefore we wish to measure the volume of a gas, we must proceed as with the temperature formula indicator, namely, to measure the volume at some normal pressure; or, what is much more convenient, to measure it at the given pressure, & by simple application of the formula (2) reduce the volume to a normal one. If we wish to reduce the observed volume of a gas (at any observed temperature & pressure) we should be obliged to take into account not only the variation of volume caused by temperature but also the variation due to pressure.

We would then be obliged to combine the two equations expressing the law of variations for temperature (1) - & the formula for pressure (2) thus.

General Formula

$$V' = \frac{V}{1 + (0.00366 \times t)} \quad (1) \quad V' = \frac{VP}{P_1} \quad (2)$$

Combining we have

$$V' = \frac{PV}{P(1 + (0.00366 \times t))} \quad (3)$$

Where however the normal temperature

is to be 0°C. & the normal Pressure - ⁶⁶
the pressure of 1 atmosphere at the ^{Do.}
level of the sea i.e., 760 ^{m.m.}; the
value of P' becomes fixed - & we
have.

$$V' = \frac{PV}{760^{\text{m.m.}} \times (1 + 0.00366 \times t)} \quad (3)$$

& V' the volume of the Gas at 0°C.
and 1 atmosphere pressure normal.

A formula continually used in
Chemical investigations.

Gas volumes are always measured in glass tubes over mercury, but as it is impossible to measure the volume (absolute) of a gas - because of the irregularities in the width of the tube - as no tube can be made of the same calibre throughout its whole length - these irregularities are overcome, by measuring successively the contents of the tube, by pouring into it, the same quantity of mercury - & reading off with the telescope - the space

Ditto

66

which this same volume occupies
in different portions of the tube



differences

a	40	41.8	} 10.9
d	30	30.9	
c	20	20.4	} 10.5
b	10	10.	

It will be seen
from the figure
that the spaces
of each reading
are different - the
successive differ-
ences being 10.9 &c

If now we assume some hypothetical
value for the small volume of Hg.
we can obtain the true value of each
division of the Endiometer, referred
to this arbitrary standard.

If we take this value to be 3/3.
10.9 - the greatest difference
between 2 readings - we should
proceed for finding the value of
each millimetric division as
follows.

Between c & b - the value of 10.4 ^(divisions) is
in reality 10.9: the value of 1 division
is

$$10.4 : 10.9 :: 1 : x \text{ or } x = \frac{10.9}{10.4}$$

Between c & d.

$$10.5 : 10.9 :: 1 : y \text{ or } y = \frac{10.9}{10.5} \text{ &c &c}$$

Calculation

Brating

Make all the necessary readings An actual
 with the telescope - with all due Measurement
 precautions - & reduce the volume
 by the formula (3).

$$\text{Volume read} = 250.6 \text{ mm}$$

$$\text{Level of Hg. below} = 650.8 \text{ mm}$$

$$\text{Barometer std} = 752.2 \text{ mm.}$$

$$\text{Temperature} = 20^{\circ}\text{C.}$$

Then to get the true pressure under
 which the gas acts we must
 subtract the column of Hg above
 the level of the trough - & this
 again from the true Barometric
 height - because this column of Hg
 acts in opposition to the Bar-
 ometer.

$$\begin{array}{r} 650.8 \\ 250.6 \\ \hline 400.2 \end{array} \quad \begin{array}{l} \text{Opposition to Barometer} \\ \text{the column Hg acting is} \end{array}$$

$$\begin{array}{r} 752.2 \\ 400.2 \\ \hline 352.0 \end{array} = \text{actual pressure on the Gas.}$$

Then find the number in the
 tables of Correction corresponding to
 250.6. & we have for the
 reduction formula (3)

63.

$$V' = \frac{(\text{tabular number for } 250.6) \times 352.2 \text{ mm}}{760 \text{ mm} \times (1.00366 \times 20)}$$

V = volume at $0^{\circ}\text{C.} + 760 \text{ mm Press.}$

Sp. Grav.
of
Gases

The most important determination by far, is, that of the specific gravity of gases - The sp. gr. of these bodies stands in the most intimate relation to their chemical nature - so that - that determination once made gives us a key to the nature of the gas. Difficulty of Determ. is great - Not felt by Solids & liquids - It is i.e. impossible to weigh them simply as with solids or liquids - & then compare an equal volume of air with them - We know that in air (as in water) - a body is bouyed up by a weight equal to that of the volume of (water) Air displaced - & it will be seen at a glance - that by weighing simply a flask or flask of a gas - the error obtained by balancing this flask with small weights will be great - & in some cases even amount to more than the actual weight of the gas.

Lecture 11th

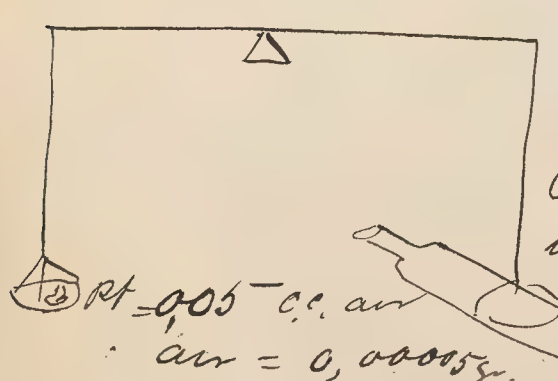
64

The value of the french system of weights + measures. If we wish to know the capacity of any vessel - we have only to determine the weight of water which will go into it - & as the relation between weight + volume in the system is known for H_2O + founded upon it, we have the volume. 1 Gramme of H_2O = 1 Cubic centimetre of volume. the number of grammes of H_2O then that go into a flask, just so many cubic centimetres does it contain.

The error in determining the Sp. Gr. of gases - of weighing in air - is very great as already mentioned.

An example of Sp. Gr. of Gases
errors of this nature

Plat. with platinum weighed would give us as



$Pt = 0.05 \text{ cc. air}$
 $air = 0.0005 \text{ gr.}$

$1 \text{ cc. } H_2O$
 0.0023 gr air

(Error)

If we could only weigh into weights of the same substance which we are weighing.

Failure
in weigh-
ing gases

60.
When we weigh with small quan-
ties this failure is so small that
it may be overseen.

When we use capsules & flasks
the error is tolerably large - but
if we weigh the flask - first - &
then the flask with the substance
to be weighed - we eliminate the
error - of buoyancy of the flask -
& become only the error of bouyan-
cy of the substance itself, which
is generally very small. In chem-
ical Analyses therefore we follow
this system of weighing & use
very small quantities of the
substance to be investigated.

When we wish to weigh gases.
we are met by difficulties on
every side - because the volume
of small weights is immense
& hence the error of buoyancy
very great. To subtract the
weight of the air displaced
would - be an exceedingly round-
about method - & useless; when we
have a much simpler method of determination

One way of eliminating this ⁶⁶ error is to weigh the gases - in flask - & balance upon the other side a flask of equal precisely equal dimensions. Sp. gr. of Gases

Then. form a vacuum in both flasks - let in one flask, air -

& ^{place} ~~weigh~~ upon the other side - weights to determine the weight of air ~~in~~ ~~flask~~. Note also the temp & Press.

And reduce this volume to 0°C & 760 mm pressure. This has been

done with greatest accuracy, but has been found that - 773 Cubic C.

Air = 1 gramme or 1 C.C. = $\frac{1}{773}$ gr.

or $\frac{1}{773}$ of H_2O , This value is somewhat different at the Equator - on acct of the variation of the intensity (less) of gravity - but so small is the difference - that the chemist can overlook it.

The problem for Specif. Grav of a gas or vapor is then to determine the weight of 773 C.C. of that gas and to compare this weight with that of an equal quantity (by volume) of air.

Sp. gr.
of
Gases

In carrying out the problem, we must make the weighings into the flasks - both of equal volumes & weights.

This is done, by taking tubes & blowing them together at the end - Drawing out the ^{other} end to a capillary tube. Then try the volumely filling with H_2O , if the volumes are different, as may seem by the volume of H_2O . Bring into the larger tube glass sticks of the volume, equal to the difference of the volumes of the tubes. This volume of glass we determine from the specif. ic gravity of glass

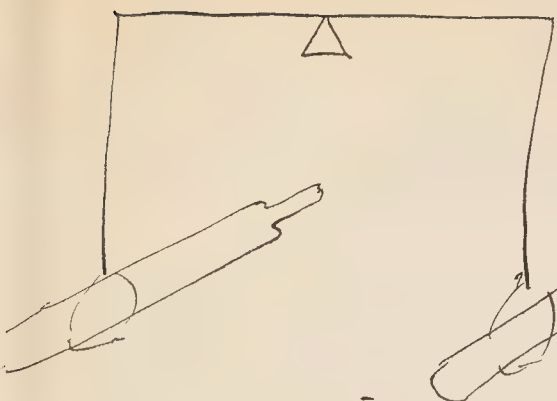
Vol/glass : 2.5 :: x vol's : x grms

Heigh off this weight of glass in fine pieces which I bring into the capillary tube of the larger flask.

One Problem is satisfied -

Now to get the weights equal.

See how much one tube weighs more than another, & add this weight, in weighing, to the lighter tube by laying small hairs of glass by its side until the two weights are equal.



Make the tubes
vacuum & then weigh the quantity of air. Ditto

Form again the vacuum in the tubes and bring into the tube the gas whose specific gravity is to be determined and find how much weight must be brought upon the other side to restore the equilibrium & the problem is finished - for we need not reduce even the gas volumes to $0^{\circ}\text{C.} + 760 \text{ m.m.}$ that is if the weighings are only conducted at the same temperature & pressure the relative weights of the gases will remain the same, by any change & that is all that is necessary. The law of expansion & Mariotte's law shows that for gases at any temperature and for any pressure, the increase or decrease in volume is a certain fixed & constant quantity - for each temperature & a cer-

Ditto

69.

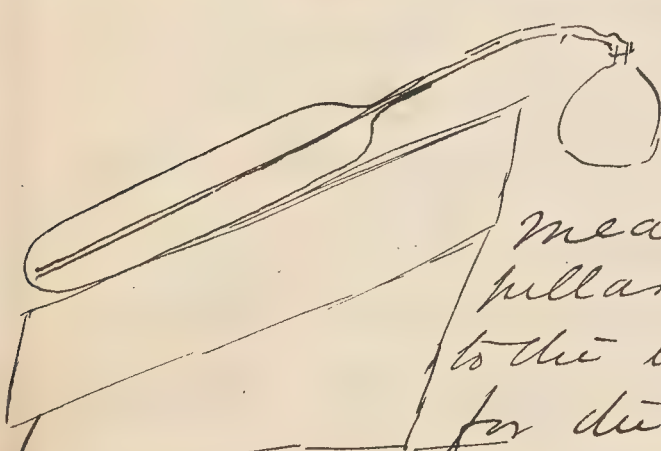
tain definite & constant relation for all pressures.

Hence be the temperature & pressure at the time of weighing, what it may - It is only necessary that the temperature & pressure upon both sides of the balance (hence of the tubes) be the same; for then both gases will have expanded or contracted from their normal volume at $0^{\circ}\text{C.} + 760^{\text{mm. Barom.}}$ in equal degrees & their relative weights will be the same, as though weighed at the normal temp. & Press. When the precautions here mentioned are judiciously observed, the determination of the Specific gravity of gases - is one of the simplest problems in the domain of the Chemist, & can be carried out with infinitely small failures from the absolute result. The determ. of specif. Grav. of vapors - will be described in the next lecture.

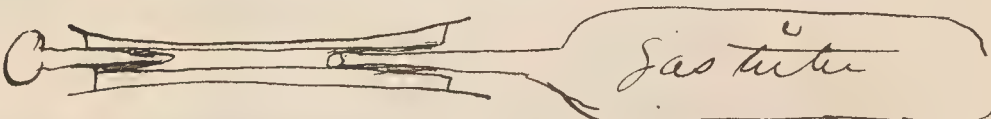
Lecture 12th

70. Sp. gr. of gases

Call ^{the} weight of air P_a , of gas P_g , then
 $P_a : P_g :: 1 : \text{sp. grav. of gas}$ for any
temperature & pressure, provided that
conditions are equal in both tubes.



Fill the gas tube
with the gas by
means of a fine cap-
illary tube - running
to the bottom of the vessel
for the gas - Seal it
not before the flame, but by means
of a tube, inside of which is a caoutch-
ouc tube - & then furnished with
a glass stopper. Bring this over the
glass gas tube, & it is hermetically
closed

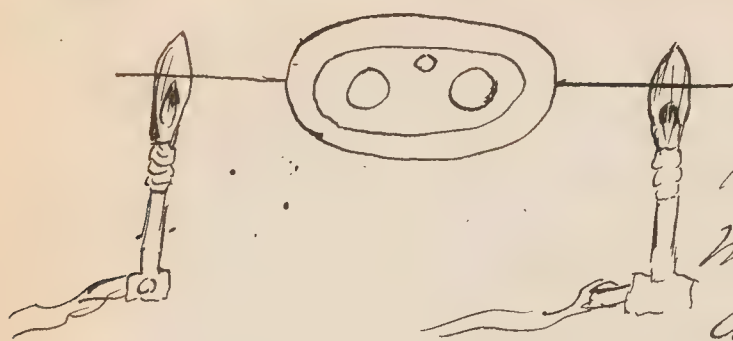


By this means the tubes may be
repeatedly used, for similar work.

This all finished it only remains
to bring the 2 gases (air & the
to be determined gas) - at the same
temperature.

This is accomplished by means of

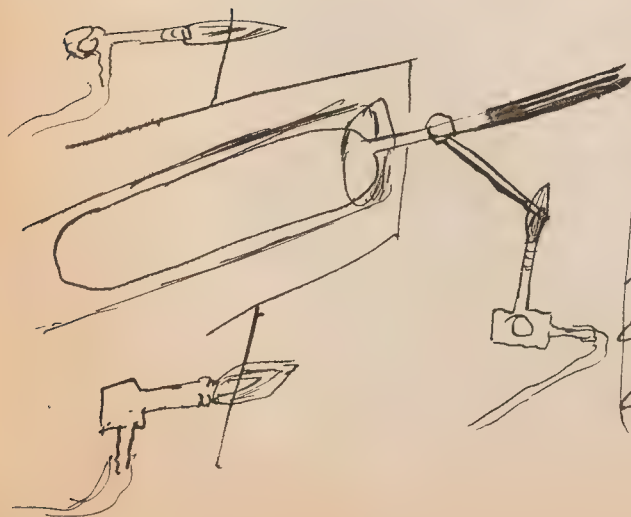
vapors 71
the thermostat:



The inner cylinder^d is only heated by radiation, & of this means must be at the same temperature at all parts - Within this are two smaller ones - ~~one~~ for reception of tubes - vessels &c, above may be seen a smaller opening for receiving a thermometer - for noting the temperature - The two cylinders are now closed by doors that fit into them - & the gases are now lead into the tubes - through CaCl tubes - to dry them - & then by capillary tubes into the gas vessels -

Sp. Grav. of vapors.

at ordinary temperatures they are liquids.




a portion of the fluid is brought into a gas tube heated in the thermostat until all the liquid is vaporized - Should now, the temperature be, by any accident, lowered

a part of the vapor would be condensed - a vacuum be formed - & air would rush in the opening - To avoid such a calamity - a ring of metal (Cu) to which a wire is attached - is fastened to the neck of the gas tube, which may be heated gently by a lamp. Particles of the vapor passing from the neck of the tube reach the piece of platinum wire placed further along in the neck, condense upon the cold metal & form a globule of fluid, which can not pass backward without generating vapor - this would force out any air, that might attempt to rush in - upon any lowering of the temperature.

Sp. Gr.
of
vapors.

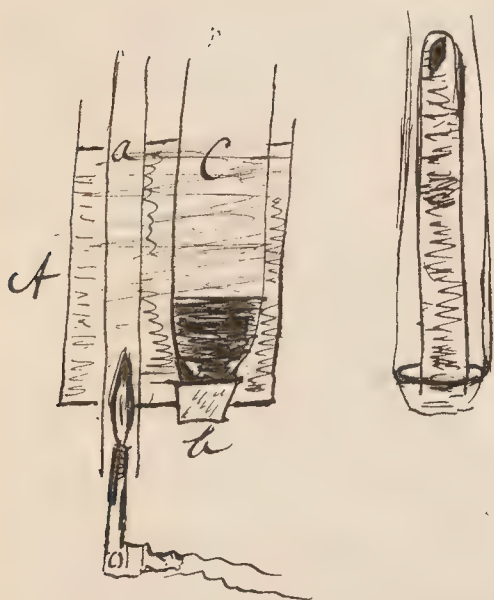
With small quantities -

Weigh the liquid - with precaution of weighing in an hermetical sealed tube. Draw out to very fine capillary tube at both ends a very small bulb  & weigh accurately, then suck up the tube full of the fluid, & smelt together the ends. The gain in weight must be the liquid, & save it from loss by evaporation. We must now convert that liquid into a gas & weigh it at 0°C & 760 mm Barometer.

Do

79.

The apparatus for this purpose is somewhat as follows.



The outer vessel (glass) A is perforated into 2 openings, through one of which is fitted the porcelain tube a which serves as a chimney, & as a means of heating. The 2nd opening is filled with a

Caoutchouc plug b upon which rests the glass tube C containing Hg. The outer vessel A is now heated by the lamp seen below, & filled with H_2O . The globe of vapor liquid, whose weight is known is now forced up another tube b (filled with Hg) ^{which is} placed within the larger tube C, upon the Hg within which it rests - the heat of the water soon communicates itself to the tube C. bursts the glass globe, by the expansion of the liquid within, the fluid is converted to vapor - the volume of which is measured by the telescope, from the etched tube b. We have now all the necessary data for the sp. gr. determination. Weight of liquid - volume at a certain temperature - & pressure.

We have only to reduce the volume to what it would be at $0^\circ C.$ & 760 ^{mm} & it is done.

Lecture 13th

Composition of			of air in Water
air	$\begin{cases} O = 0.21 \\ N = 0.79 \\ \hline 1.00 \end{cases}$	$\begin{cases} O = 0.3491 \\ N = 0.6509 \\ \hline 1.000 \end{cases}$	

On the calculation of vapor density it is only necessary to reduce the temperature & pressure - after vapor to 0°C + Pressure 760 mm.

We now come to combinations of the elements -

Combination
of
Bodies

1. Mechanical mixtures -
2. Solutions
3. True Chemical Combinations -

We have only to do with the last two,

No laws - can rule mechanical mix-

tures - they are interesting to us on that account, because, we are often able to separate, true chemical compounds from them - by the simplest means - & thus by their presence - arrive sooner at the real nature of an unknown compound.

Mechanical We can mix substances in all
Mixtures proportions - independent of the
 Chemical + physical nature of the
 body - We have

- 1) Mixtures of Solid + Solid
- 2) " " Liquid + Liquid
- 3) " " " " Solid
- 4) " " Gas + Gas
- 5) " " " " Fluids
- 6) " " " " Solids

1st. of Solid + Solid.

Of such mixtures - there are infinite
 numbers - may be fine or coarse grained.
 One may be distinguished simply by
 the eye as a mixture, for example,
 Granite; the other can not be
 seen by the eye to be else than a
 simple body - Kupfer schnefer -
 To determine the mixture exam-
 ine it with the microscope -
 about 40 times magnifying,
 then the particles of the mix-
 ture will be plainly seen. That
 is we will observe that the particles
 of the substance - are not homogeneous
 but heterogeneous - possessing different
 Colors - &c. &c.

or again, we may powder it, ^{7/6} Ditto
& then pour water upon it -
the specifically heavier body
will sink more rapidly to the bottom
than the specifically light ingredient.
& by successive decantations we
can separate the constituents perfectly.

Liquids + Liquids - (Emulsions),

mechanical mixture of liquids.

Iodine + CO_2 + HO)

Liquids + Solids. \rightarrow very abun-
dant in nature - water - streams
&c. always carry mechanically
mixed with them - mud & sand -

In Chemistry, mechanical

means &c - serve us to separate
precipitates - which is only

mechanically mixed with the
menstruum - filtration is the

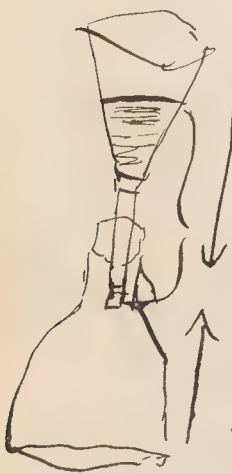
means - generally of separation
Decantation - at other times.

all foreign particles are removed
by passing the liquid through a
partition of paper (generally) - upon
which the mechanically held-
precipitate is left behind.

Filtration

The velocity of filtration in all cases is proportional to the difference of pressure - above & below the filter -

If we increase the height of the pressing column - we directly increase the velocity of filtration.



If we increase the difference of pressure - by creating a partial or complete vacuum in the flask we increase the velocity of filtration indefinitely.

The difficulty of breaking the paper filter is overcome by protecting the unsupported part by a Platinum cone fitted to the inclination of the funnel.

The benefit of filtering under great pressure is so great that in all large operations the work is accomplished in one-tenth the time, as by the ordinary method - Not only does the operation of running through proceed more rapidly - but the precipitate is left almost entirely dried - behind & the tedious operation of washing - is avoided - & the precip. can at once be burned.

Mixtures of gas into gas.

Highly interesting to the chemist,

Diffusion

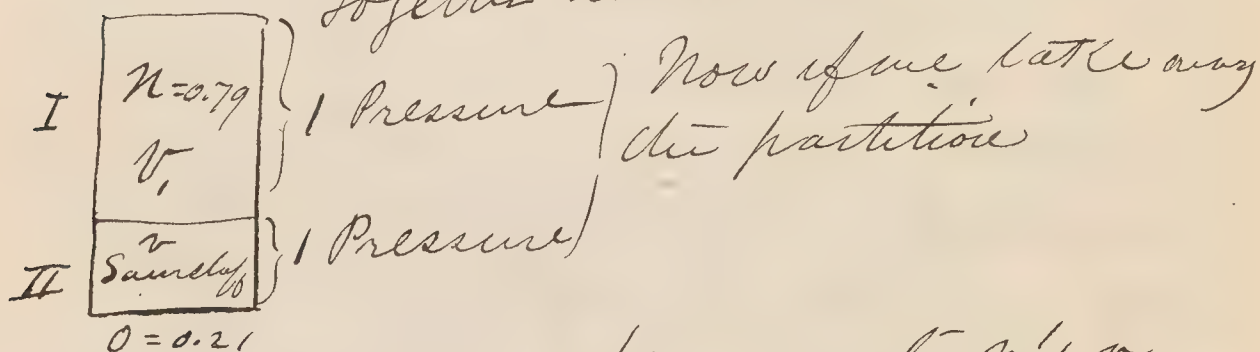
To illustrate the mixture - a pair of bulbs containing Bromine-vapor & Chlorine - bring these into 2 tall flask & notice that the gases will not come to rest in obedience to their specific gravities - If even, we place the specifically heavier gas below the other, it will rise & mix itself intimately with the other - Show the diffusion with air, with each gas separately with air - first - (Show bleaching by litmus paper to prove motion) - This phenomenon - is called the diffusion of gases - & takes place with each gas as though no other gas was present.



In the jars below are two globules filled respectively with Cl & Br - when broken - the gases though specifically much heavier than air - will be found in a short time to have risen & uniformly to have filled both jars. Show by coloration & bleaching -

79
The particles of the diffused gases exercise a pressure upon each other - which makes the perfect occupation of the whole space by a gas - a slower affair - much slower than in a vacuum.

If we have vessel with a partition & above one gas & below another together the volume make = V



$0 = 0.21$
 v_1 will be in a few minutes $v' + v$ but by altering its volume it has altered its pressure. We know the law

$$v' : v_1 + v = p : 1 \quad \text{or} \quad \frac{v_1}{v_1 + v} = p_0 \quad \left. \begin{array}{l} \text{the new} \\ \text{pressure} \end{array} \right\}$$

The same is true of the oxygen. It soon has the volume $v + v'$ so that we have

$$v : v_1 + v :: p : 1 \quad \text{or} \quad \frac{v}{v_1 + v} = p_0$$

80.

The whole pressure is then represented by

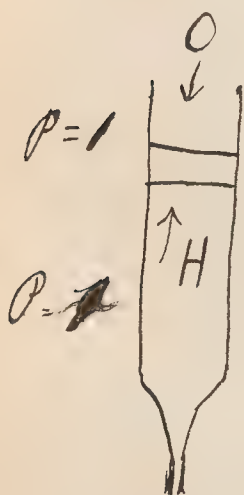
$$\begin{array}{r} p_o = \frac{v_o}{v_o + v} \\ p_i = \frac{v_i}{v} \\ \hline \frac{v_o + v_i}{v_o + v} \\ \hline 1 = 1 \end{array}$$

The whole pressure is the same as before - only the relative pressures exercised by the mechanically mixed gases respectively is a different one after the diffusion than before it. Further remarks on this topic next-lecture.

Lecture 14th

Diffusion
of
Gases

The air is composed of $\begin{cases} O - .21 \\ N - .79 \end{cases}$ so that the pressure being in total 1. each constituent experiences its proportionate part of the pressure, which is represented by its compression by volume.



With what velocities will 2 mixed gases go over to each other? -

the composition of gas within

H presses with $P = 1$

Diff. of Pressure

after the first moment the conditions within the tube ^{would be} different - so that the velocity in each succeeding second - would gradually take off.

Difference of pressure = 1 in 1st sec
(S = amt of O which is introduced into the tube in 1 second)

Difference of pressure = $1 - S$ in 2nd sec
" " " = $1 - S_2$ in 3rd sec
" " " = $1 - S_3$ in 4th sec

The O would lose nothing of its pressure without the tube - but the pressure within would gradually be equalized till all further diffusion

would cease.



The difference of pressure - Exp producing, a difference of diffusion creates a partial vacuum - which can be shown by filling a tube with a CaSO_3 plug - & place it at once over the vessel of colored liquid - h. which will rise rapidly in the tube.



The errors that may be brought about by this diffusion, are enormous. The slightest opening in a vessel containing gas will not only permit the contained gas to escape - but the surrounding air to enter.

The catch & preserve gases in the following manner - Mineral Spring To col-
lect Gases



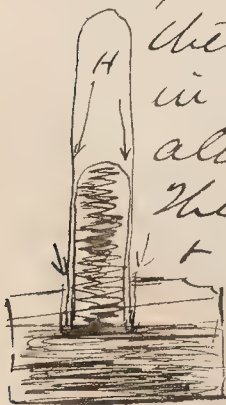
Gases. - a long necked bottle is drawn out to a tolerably fine tube (see a) - then filled with distilled water, a caoutchouc cork into which is fitted a funnel - is then set upon it - and thus arranged it is placed below the surface of the water - the rising of the

Do.

Gas promoted by gentle shaking beneath the surface. When entirely filled, the funnel - is taken off a - solid cork fitted on (beneath the H_2O), the flask gently heated - & then cork taken out for an instant to allow the expanded gas partially to escape, that the pressure without of the atmosphere, be greater than that of the gas within - The fine part of the bulb is then melted off - & the gas may be preserved - for years - without becoming impure. This process is generally adopted when we wish to analyze the gas at once, when the gas is to be preserved for a long time - 'tis safest to use the flask not drawn out - & cover the cork with Carouane leaf & sealing wax.



Hydrogen can not be kept (nor even other gases - for a long time) a long time without changing its volume - & being filled with impurities - When kept above Hg -



there will be a slow diffusion which in course of time - will entirely alter the nature of the gas - for - the Hg does not wet the glass - & as a result - there is always between the Hg & glass - an infinitely small capillary channel through which the air - can diffuse from without into the tube - & vice versa - the H - (or other gas) diffuses into the atmosphere. When analyzed at once the failure is imperceptible.

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The find that boiling at 0.76 metis. Evapora
with H_2O takes place at $100^\circ C$ - tions

We find however - that if we allow
a vessel containing a fluid - to
stand open - in contact with the air
in the course of time - it will entirely have
disappeared - even at ordinary temperatures.

When we take into consideration the
phenomenon of Diffusion ~~into~~
the fact of evaporation, explains
itself - Within the fluid itself can

never a particle of liquid be converted
into vapor - until the temperature has
arrived at $100^\circ C$. at the usual pressure.

But upon the surface the matter
is different - the particles there
have the tendency to convert them-
selves into vapor, & the tendency to
diffuse into the heterogeneous, gas vol-
ume above it - & here - upon the
surface - only the phenomenon of
evaporation will take place -
if the atmosphere above the liquid
be free the evaporation will take
place indefinitely - till no more
liquid remains - but - if it be closed
the evaporation will only take place
for a short period & then altogether
cease.

Tension of
Aqueous
Vapor

We have seen that between two gases of the same nature - ($H \& H$ for instance) when brought together under similar conditions of temperature & pressure - no diffusion takes place - the particles mutually preclude & have no tendency to interchange places with one another. With heterogeneous gases the contrary is the case - & the particles move amongst each other as in a vacuum till the whole space given them is equally filled by both. This is likewise the case with a fluid (liquid) & a gas. The phenomenon of evaporation is nought but a diffusion of the particles upon the surface of the liquid, among those of the gas. When the diffusion has become an equal one - the evaporation ceases - for the particles of the liquid - are now opposed by those of the homogeneous vapor - with changes of pressure & temperature the point of the cessation of evaporation will be different, but for a given temperature & pressure the amount is constant - The change in the volume of a gas brought about by the presence of H_2O vapor - must in all gas analyses be subtracted from the Bar pressure under which it stands. This factor - is the Tension of aqueous vapor which has been calculated with great accuracy by Regnault & others.

Lecture 15th

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The formula then for reducing Gases
the volume to a normal one Con.
in gas analyses, becomes altered
by the addition of this small fac-
tor - namely - the tension of aqueous
vapor for the observed temperature.
It then becomes - calling this factor t_1 ,

$$V_1 = \frac{V (\text{Bar.} - (b - t))}{760 \text{ m.m.} \cdot 1.00366 t}$$

where b = the height of Hg above the trough.

Where it is desired to dry a substance
completely - or to evaporate a

fluid (H₂O) containing salts in
solution. We use a desiccator

a vessel of SO₂ (concentrated)

is shut off from contact

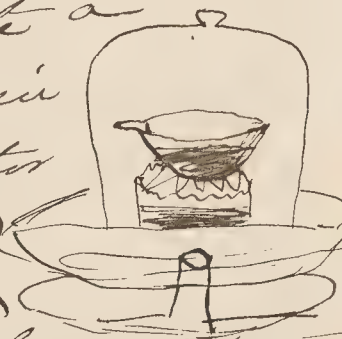
of air - & the liquid to be evaporated
or the salt - is placed upon it - as seen
in the figure - Upon the air pump -
the rapidity of the evaporation is increased.

Mixtures of liquids & gases.

of the greatest importance -

of a certain flask of H₂O, be boiled

till all gas - be expelled - then set
out into the air. The result will
be that Oxygen - will be absorbed



The
Desiccator

Absorb-
tion

Ditto

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and indeed for every temperature
a constant quantity - of gas - as
well as for every pressure, as will
be seen hereafter. — →.

By increasing the surface of the
liquid we increase the rapidity
of the absorption otherwise we would
be obliged to set it out to the
gas for many days before the liquid
had absorbed all that it could take up.

Is this phenomenon a chemical
solution or mechanical mixture?
This question is slightly answered -
+ the conclusion is that it is
nought more than a mechanical
phenomenon. For —
If with this oxygen absorbed
we bring the fluid into an
unbounded atmosphere of Hydrogen - the oxygen will be
completely driven out + H will
enter - while again, if the con-
ditions be again reversed - + the li-
quid be set out to an unlimited
atmosphere of oxygen - the
Hydrogen - will be in its turn
driven out, and the oxygen
will return to its place.

88

This absorptive power of various fluids for different gases is a very different one - at the same temperature & pressure -

The quantity of gas absorbed is Law of Absorption dependent upon 'the nature of the gas' - & ~~from~~ ^{upon} 'the nature of fluid'

The quantity of gas which a unit of volume of H_2O will absorb. at ~~the~~ $0^\circ C.$ & 760 mm. Pressure is called the Coef. of Absorp. Coefficient of absorption for that gas. Coef. of Absorp. of Gases. Coefficient of absorption, ^{is} depends out of course upon the nature of gas & liquid (for $C_4H_6O_2$ the Coef. of abs. is diff. from H_2O) 2nd The Coef. of Law of absorption decreases with the Coef. of temperature -

3rd Coef. of absorb. increases with the pressure - & indeed directly proportional with the pressure.

With thrice the pressure - twice the amount of gas is taken up by a liquid - with thrice the pressure - thrice the amount of gas &c. &c.

By removal of excess of pressure the normal amount of gas at 1 atmosphere will remain behind in the liquid. Mineral water & Champagne &c. contain gases absorbed under pressures varying from 3 to 6 atmospheres - consequently when the normal pressure is restored the excess of absorbed gas escapes violently.

Mineral
Water.
Champagne.

Should we attempt to collect gases over water - the greatest failures would result - should we attempt to keep them for some time above H_2O - No result would be obtained for if a part of the original gas volume remains - it will be one of a foreign gas which the water had been held absorbed.

We therefore use Hg - for the purpose of catching & keeping gases.

In collecting of mineral waters, the greatest care must be taken, to prevent the loss of the CO_2 & other gases which are universally held absorbed by various mineral waters.



The method pursued in col. I. Hunt's collecting mineral waters with following.

The flask which is to contain the mineral water is lowered - & corked to the bottom of the spring - then the cork is removed - & the water allowed to displace the air. At the bottom, however, the gas is held in greater quantities than upon the surface of the spring; therefore because of the greater pressure at the bottom - therefore we obtain a liquid richer in gas than were we to collect at the surface - & upon raising the flask to the surface - the excess of pressure being removed - the gas would slowly escape - till the normal quantity was held in the liquid - the small space a in the figure - would then be filled with gas & no absorption would take place of a foreign gas - no matter how long the flask should remain - provided of course the flask were then corked. No mineral water that effervesces can be rightly be analysed - for a foreign gas has entered the fluid & displaced the natural one.

collect Mineral Waters

Dependence of Organic Life

Upon the absorption of gases by H_2O , chiefly of O - all the organic life of the waters depends - & analyses show that some singular irregularities prevail.

Compos- 91 The composition of air in water
 sition of
Air in H_2O in H_2O $\left\{ \begin{array}{l} O = .0.3491 \rightarrow 0.21 \\ N = \frac{0.6509}{1.000} \rightarrow \frac{0.79}{1.00} \end{array} \right\}$ in air

So that the air in the water has about $\frac{1}{3}$ more oxygen in its composition than the air passages. So that a water animal - though not having so much air in such a small space - as a land animal but, withal in proportion to the amt - absorbed a greater proportion - is able to live.

Extrac- It is often of great importance
 tion of to be able to remove from the
Gases from waters of mineral springs, the
Spring H_2O gases completely - for analysis.
 It is accomplished as follows.
 The mineral water is collected in the manner described on page 90. & must upon opening of the flask, not effervesce. If these conditions have been fulfilled - the extraction of the gases & their analysis can be easily accomplished.



Fig 1.



Fig 3.



Fig 2.

Do

Figure I-
C is a flask for
containing the
spring water, and is
either filled as described
on page 90. at various
depths - or if the gas is
in a larger flask (90)
it may, by transferring

the liquid gently from the large
flask with the syphon - into the
smaller one - be filled without loss.
Connected with it, is a caoutchouc
tube fastened around its neck by a
twisted wire, within this caoutchouc
tube is a loosely fitting glass tube
rod. (seen at a) by pressing upon
which, communication can be cut
off between the flask A. & flasks
B & C, but which in its normal
condition allows the passage
of the gas - The bulbous tubes B & C.
are shown in figure 2. The tube B. is
now partially filled with freshly
distilled water. & the apparatus fitted
together as seen in Figure 3. The
flask A - being completely filled with Mineral
Waters

91
Ditto Mineral water. The whole apparatus is placed in a slanting position & the flame of the lamp is applied to the water in the bulb B, while at the same time the stop-cock (at d) is opened. The consequence is that in a short time the air will be completely driven from C. & the bulb filled with watery vapor. The lamp is removed & the stop cock closed. The vapor ~~now~~ condenses - & the bulb & tube C - becomes more or less completely a vacuum. The gas in the mineral water - (in A) is under less pressure - the gas commences to escape & by the application of gentle heating can be completely expelled from the fluid.

When all the gas has escaped - (as may be seen from the bubbles - (that is the small ones) disappearing) The glass is smelted together at f & f' - (having previously by tilting up the flask A - allowed the H_2O to reach as near f as possible). We now have the gas in C. by bringing it under Hg. & breaking off the point f' - we can bring it into the Eudiometer & measure it - we know the volume of H_2O in A. & know now also the volume of gas which it contained, it only remains to analyze it.

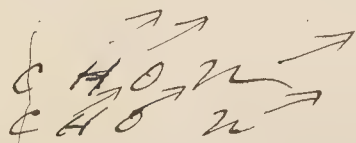
Lecture 16thCatal-
ysisMixtures of solids + gases

all solids when brought into contact with a gas - by means of capillary - attraction have the power to take up - within their particles of the gas.

The action only takes place only at the infinitely small distances,

But by increasing the surface of the solid - we increase the amount of condensation of gas.

And this we may in some cases to do. - For instance. Wood, by burning - gives up an immense surface.



The carbon particles retain their place - & take up gases upon themselves. The phenomenon has not been so accurately investigated as the absorption phenomena.

This condensation of gases is dependent

95.

1st Upon the Nature of the Solid & of the Gas.

2nd ^{condensation} They decrease with the ^{temperature} ~~pressure~~

3rd Increases -- & perhaps directly with the pressure.

Exp

showing the absorptive power of freshly burned charcoal.

Solution

1st characterized by the fact that it can only be brought about - when the particles of the dissolving & dissolved body are actually in contact.

2nd - The physical properties of the dissolved body - are more or less changed - which by the mechanical mixtures was not the case.

Solution

We may consider solutions of

Solids	+	Solids	} the Six possible cases,
Solids	+	Fluids	
"	"	Gases	
Liquids	"	Liquids	
"	"	Gases	}
Gases	"	Gases	

Of solids with solids.

96

Do

Copper - & Zinc - 2 peculiar metals
One of a peculiar red color - the other of
a greyish tint - which possess peculiar
Specif. gravities - &c. when brought Brass
together in the smelted state - dissolve
in one another, so that upon cooling
we have a solution of solid with
solid - a body possessing very different
physical properties from any of its con-
stituents - without the mean sp. grav. &c
The Alloys generally belong to this Class.

Fluids with fluids.

With fluids we can observe the
phenomena of solution - accom-
panied by the changes in the phys-
ical properties of the bodies engaged
much better than with the 1st Case.

If we mix two fluids of differ-
ent specific gravities, or rather
bring them into contact with
one another; we observe the same
~~properties~~ phenomena show them-
selves as with - the diffusion of
Gases - namely - though the specif-
ically heavier fluid may be below
& the specifically lighter one above;

Do

97

The particles of each will find their way into those of the other - against the influence of gravity. The physical characters of the fluids color &c specif. gravity - will be arbitrary - & not the mean specific gravity of the constituents of the solution. In this regard being like Solids with Solids."

Exper - We may dissolve C_4H_5O into water - but only a certain quantity, when a certain quantity has been taken up - of each ingredient - no more shall can be taken up.

This point is called the point of Saturation for the bodies involved.

The Saturation point is dependent upon \Rightarrow

1st The Chemical nature of both fluids -

2nd Upon the temperature - the solution is aided by increase of temperature.

The physical properties of the resulting solution may be

Such as to have no resemblance to those of the constituents as has Ditto, been previously mentioned. Though color of the characteristic liquid is the prevailing one of the solutions, one solution may be destroyed

by the presence of a liquid, for which one of the constituents of the solution has more affinity ~~for~~ than CS_2 for its first solvent:—for example Iodine dissolved in H_2O - If CS_2 I. is brought into contact with it, all Iodine will be removed from the H_2O - & be taken up by the CS_2 .

Solids + Liquids.

There are here certain definite laws regulating these phenomena.

Physical properties are not the mean physical properties of either sp. gr. - as with solids + liquids, &c., may be entirely arbitrary —

If we bring more of the solid to the liquid — ^{we} finally reach a point of saturation. where the water - refuses to take up any more of the solid at that temperature.

99

This point is as with solids & liquids - dependent upon
1st The nature of the solid & of the liquid solvent.

2nd - The temperature. (+ increases with increase of temperature).

at Each temperature with given solid & solvent - there is a certain given saturation point.

So that if we wish to separate the solid from the solution - which is

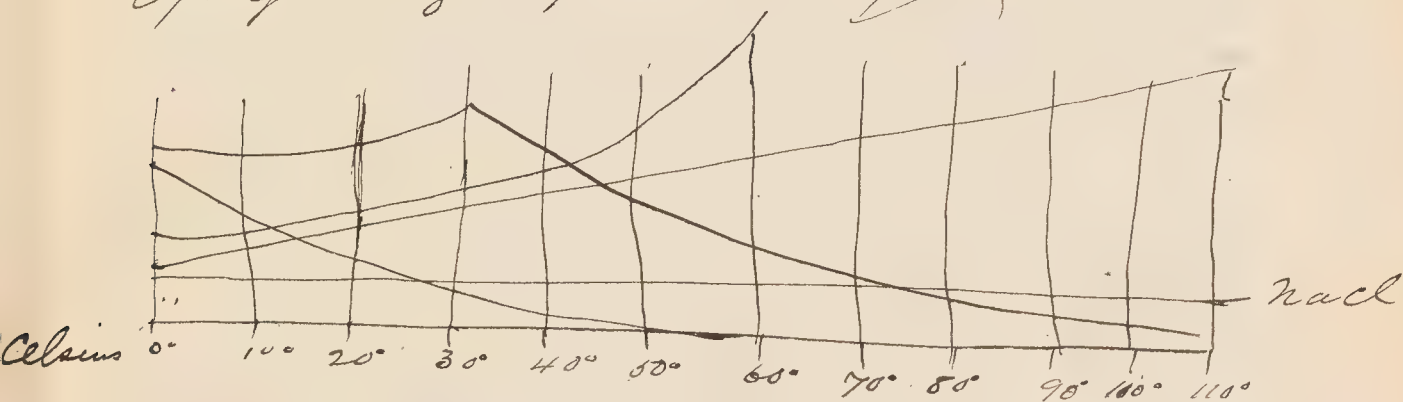
Crystallization - saturated one, we have only to allow it to stand out, for a time at a lower temperature, & the solid will

Distillation in part crystallize out.

Or we may boil the solution the boiling point of which is generally above the normal boiling point of the solvent; when the solvent (H_2O , $C_4H_6O_2$ &c) will distill over leaving behind in the retort the solid constituents of the solution, when all the solid contents of a solution are needed - this method is always adopted as the surest & best.

Ex \Rightarrow Distill solution of CaO & CO_2 in H_2O

The importance of the solubility of various Salts to the Chemist is ^{very great} ~~of importance~~ - as it affords him a ready means of separating several salts otherwise difficult of separation - by means of crystallization at diff. temperatures. The solubility of salts is generally expressed graphically -



Take for a unit 100 parts of H₂O -
 & the amt of salt dissolved, at
 certain temperatures -

The curved lines then represent the
 different degrees of solubility -

The abscissa represents the temp-
 eratures - the Ordinates - the degree
 of solubility at different degrees.

Some salts - are equally soluble, or
 increase very slightly in solubility - by
 increasing the temperature (NaCl) -
 Others - decrease with the increase of
 temperature - but others increase to a cer-
 tain point & then decrease - while the most
 gradually increase as the temp. increases.

Lecture 14thExperiments in Solids.

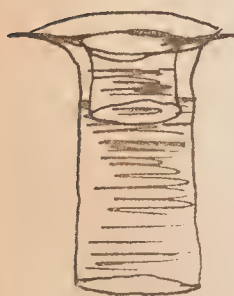
Those bodies (some of them) which have not the power of Crystallizing, have the power of dissolving liquids in them, animal membranes -- parchment - glue &c - are particularly distinguished by this remarkable property.

This solution is all already mentioned is dependent upon Chemical nature of the solid & of the fluid.

This property may be put to the most important use - It appears that such membranes have the power of dissolving or allowing to pass through them - such substances which crystallize - & only such.

If then we have a solution of gums of various kinds with also one of the organic alkaloids - which crystallize - we have only to bring the solution upon a parchment partition - & set it upon a beaker of distilled H_2O . The alkaloid will then pass through

Dialysis



Gases - + gases.

We know not whether such solutions exist - all gases as yet examined - obey the law of diffusion - with only slight variations. Should we ever meet a gas which disobeyed this law, we should have found an example of a solution of a gas in a gas.

Liquids + gases.

If a liquid + gas - disobeyed the laws of absorption then we would have an example of this kind of solution. We know of such a case - Chlorine + Water - if we examine this solution we find that the absorption - takes place independent of the temperature + partial pressure of various gases in the liquid.

Those gases which are ^{absorbed} enormously by H_2O - do not generally obey the law of absorption - because the resulting liquid is a chemical compound of the two ingredients.
HCl in water for example.

Gases in Solids

Some solids (metals) when in a highly heated state - take up - a quantity of gases - in them - Palladium for example.

True Chemical Compounds.

They are characterized that the ingredients come together in a certain - definite quantities ^(limits) not variable within certain ~~distances~~.

The properties of the ingredients are lost in those of the resulting Compound. The specific identity in other words is lost.

Exp. Sulphur + Iron rubbed together give us a mechanical mixture in which both ingredients preserve their specific identity. The Iron may be removed entirely from the sulphur by the Magnet, or the sulphur from the Iron by decanting with H_2O . But as to this intimately mixed -

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mixture - we apply heat - a
phenomenon of combustion ^{Combination}
ensues - and there results - ^{or} fixed
a body - neither Sulphur, nor ^{proportions}

Iron. Having no resemblance to
either; with entirely different chem-
ical + physical properties - the
body we call Fe S. If however, we
analyze this body - we should find
that, it consisted of exactly of

{ Sulphur = 16 parts }
{ Iron = 28 parts }

every Sulphide of Iron is composed of
exactly the same proportions of Fe + S.

Of we ask the cause of these
chemical combinations - we
find that no force which we
have yet known, is able to
explain these phenomena - of Com-
bustion - change of specific iden-
tity etc - so that we assume that
there exists within each subst. ^{Chemical}
a peculiar + definite ^{Affinity}
force - which we call Chemical
Affinity.

We are obliged to assume that: —

1st. These forces exert their action
ⁱⁿ the smallest ~~distances~~
particles of each body.

2nd. They exert themselves at infi-
nitely small distances.

3rd Every single element has its own specific affinity for each other element.

Proofs →
as
these
same

That we can mechanically separate a chemical combination to infinity without altering the nature of the comb. is proof of the 1st law. That these smallest particles are at infinitely small distances apart - is sufficient to prove the second. For the proof of the third - Fuse sulphur in a test tube - bring into the vapor - a piece of Cu foil. the phenomenon of Combustion takes place - & Cu S is formed - if now we substitute Pt. for Cu. no such change takes place - the Pt. remains bright as ever showing that the force of Chem. aff. is different between different substances.

Ex
Cu S.
+
Pt.

What causes are then from which these Chem. affinities are regulated - or increased or decreased.

1. The field for the action of affinity - time required -

Ex CaO mixed H₂O - gives us first a mechanical mixture, which after a time, changes in time

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to a genuine Chemical ~~of~~
Compound.

We explain this phenomenon,
by assuming that - a certain
opposition is to be overcome,
& like friction in mechan-
ical action must be overcome.

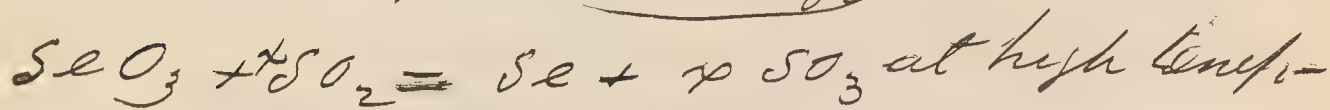
This 'Verhinderns Widerstand'
~~dependents~~ - upon a quantity
of circumstances -

1st It may be overcome by violent
shaking - ($\text{KO}^+ + \text{I}^-$) at times.
In precipitation this method is always
adopted.

2nd. It is dependent upon the Temp
temperature.

(Selen + Saurstoff)

Schwefel + Saurstoff erature



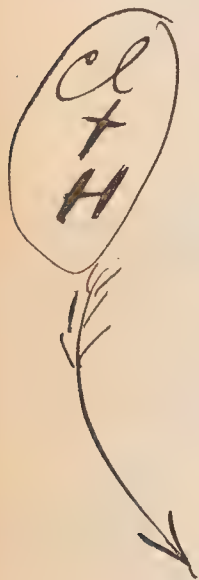
3rd dependent upon Light.

$\text{Cl} + \text{H}$ in the dark do not
act upon another.

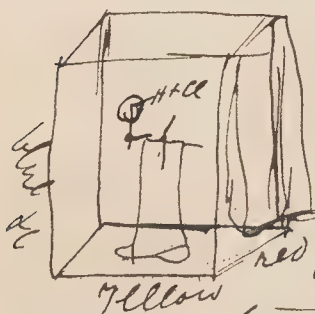
In light - by explosion they
unite.

The kinds of light which influence Chem. act. All kinds of light do not equally influence chemical action — Some colors appearing to be perfectly indifferent or neutral regarding chemical action — while other colors act singularly to facilitate it.

Ex



Chlorine + Hydrogen when mixed in equal proportions — combine to form HCl. (a gaseous acid) — If this mixture be kept in the dark, no union will be brought about. In the light of the sun — it takes place instantly & with violence.



If the flask full of H+Cl be brought into a closed box with windows of differently colored glass the combination, will not take place with yellow — or red — but with Blue + Ultra violet light instantly — as may be proven by holding a burning Magnesium wire — before the various panes.

Lecture 18th.

Electricity can influence Chemical affinity in the way of reducing these oppositions to Combination.

The presence of a third body - may influence the Combination of two other bodies - which previously would not combine.

Oxygen + Hydrogen

(H_2) Platinum.

Expt

or again $H_2O + O = H_2O_2$

Pt \rightarrow

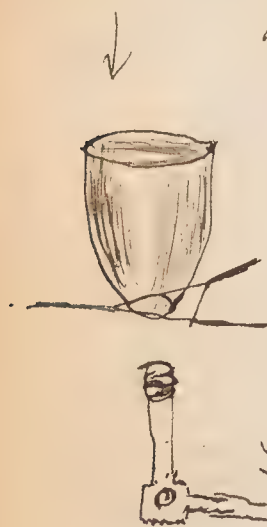
The presence of the Platinum causes - the union of the $H + O$ to water - while in the dry case it breaks up the Hyperoxide of H into Water + O - \rightarrow

If we heat a Platinum Crucible to redness before the gas flame & then rapidly shut off the stream Ex & open it again - the Platinum Crucible will still continue to

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 glow - The action of the union of the
 particles of the gas - takes place only
 on the immediate surface of the
 Platinum. {^a are gas particles} p. Platinum

Contact
 Phenom-
 ena.

a b a b a b
 p' p' p'
 a b a b a b



P. acts as a means of bringing the
 particles of the gas into more
 intimate contact, the heat of the
 Crucible - at first induces the com-
 bination of the particles of the
 gas immediately in contact with
 the platinum, the heat of the Comb-
 ination, is sufficient to keep the
 platinum in a glow - but not
 enough to inflame the gas -
 The mechanical force of the gas
 stream - continually supplying
 cold particles upon the heated
 surface.

change of
 affinity
 at
 different
 Tempera-
 tures.

We find another paradoxical
 appearance. namely - that
 at ordinary ^{no combus. occurs.} temperatures, by
 heating we find that - the op-
 positions to chem. Combination
 are overcome. & the bodies
 unite - but by increasing
 the temperature still farther
 we find that the combination
 ceases. & the particles do not unite

until the temperature is again 110°
a normal one - The here, by in-
creasing the temperature, by a given
amount - continually lessen the
Hindrances to Combustion - but Explanation
when a given temp. is passed - the Union of
affinities of the bodies is overcome the Phen-
and they lose their power of longer omenon
remaining in Combustion.

The Divisions of Chemistry.

I Pure Chemistry

a. Experimental Chemistry

- | | | | | |
|---|-------------|---|---|---|
| { | 1 Inorganic | " | " | } |
| { | 2 Organic | " | " | } |

b. Analytical Chemistry.

c. Stoichiometry

II, Applied Chemistry-

a) Medical

b) Technical

Organic + Inorganic Chemistry
were previously brought together
in one course - but Organic
Chem. has become so vast a
collection of facts - that it has
become impossible to include

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them in a course of Inorganic;

It was formerly - supposed that

the multifarious combinations produced in organic beings, were the action of peculiar organic forces, but modern researches have shown that every combination existing in the bodies of plants or animals may be produced in the laboratory.

Error of
looking
at
Organic
Compos.

Analytical Chemistry busies itself with the Separation of Compounds into their Constituents. It may be pursued in

Quant.
+
Qual.
Chem

two directions - one - which has for its object the discovery of what substances are present in a compound - Qualitative - the other - in what quantity these substances are present - Quantitative Analytical Chemistry.

Stoichiometry busies itself with the laws + forces which are existent in chemical phenomena - The theory of combinations - the laws of definite combination, of decomposition + recombination etc. etc.

11/2

Lecture 19th

Saurstoff.

Specific grav. of air = 1.00000
" " of Oxygen = 1.10561

We begin with Oxygen react.
of its importance - for a knowledge
of its compds, will carry us over
the ground of all the other Elements,

In 1774 - by Priestly discovered -

" 1775 - " Scheele "

~~Both~~ ^{Neither} ~~discovered~~ the true
nature of the substance, ^{Lavoisier} ~~found~~ founded
Chemistry upon its true ground.

It comes in the atmosphere -
mixed with Nitrogen - 20 pr. ct.,

In the organic world - Oxygen
is one of the constant constituents
of its numberless ~~constit~~ compds.

In water - that covers $\frac{2}{3}$ of the
surface of the globe - Oxygen
composes $\frac{8}{9}$ by weight - beside
which, the amt of O absorbed from
air - would add considerably to its sum.

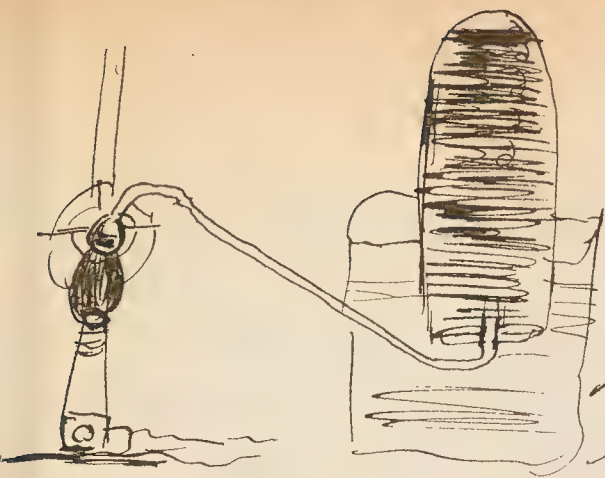
Every rock contains this substance - We are able by studying its compounds - to go over the whole ground of mineralogy - & in inorganic chemistry, by far, the most abundant & important, compounds that shall meet our attention, are the compounds, of Oxygen.

If we heat Hg to its boiling point. (or near it) unite with the Oxygen of the air & forms, HgO - When it is heated still farther - it breaks up again, into its Elements Hg + O -

Manu-
facture
from

This is One way of manufacturing Oxygen -

We may at the same time carry out an analysis of the HgO. & need only weigh the HgO - before & the Hg - after - the loss of weight is O - what is left is Hg - Or we may weigh the O - directly by determining its volume at 0°C + 760. mm.



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We are unable to
carry out our inves-
tigations with abso-
lute certainty - It

lies in the imperfections of human
sense - that we must by every-
research make minor or less error.
But the investigator may tri-
umph over them all - for we
know what errors we must
make - & then take them into
account. That is - we either -
make these errors as small &
harmless as possible, or we
make the error - but measure
it - & then in reckoning out
our result - make due allow-
ance for it.

One of these two ways we always
follow - when we make ac-
curate investigations, & we are
able by careful analyses to
make such accurate results,
that the small difference is
worthless - to be regarded as

Do.

Accounting for
Errors

We would in this case, if we wished to make an accurate analysis of the H_2O , ~~we would~~ if we wished to measure the failure - ~~we would~~ - measure the capacity of the retort in which we had generated the Oxygen. The various ways of determining the capacity of vessels has already been described. As it would have been impossible to have removed all the air from the retort we have to subtract from the volume of gas obtained - the volume of air equal to the volume of the interior of the retort - again - we must ^{add} ~~subtract~~ the volume of Oxygen that necessarily remains behind in the retort - Again - we know that an error will be met with in the absorption of the Oxygen by the water over which we have collected it. To do away with this we must - previously saturate the water used thoroughly with Oxygen gas before

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Generating the gas. Then there
will remain no possibility of
loss by absorption. We always
find however - that, be our anal-
ysis as ~~acc~~ carefully conducted as
possible - a small error is al-
ways met with - With the old
Phlogistonists this error was Phlogis-
regarded as a matter of course, tan-the-ory.
But with the foundation of
Chemistry upon firm grounds,
we have adopted as our prime
Axiom - that no matter -
can be created - nor can it be
destroyed - (ditto with Force) -
We say then - in regard to our
failure - not ~~as~~ that matter
has been lost - or that some
has been created - but that
through the imperfection of
human manipulation - we
have been unable to derive
absolutely accurate results -
And we find in substantiation

The ~~assure~~ ^{of} our position that the
Chemistry conducted - the greater the
 regard we have for the possi-
 bility of a failure → the more
 accurately our measurement
 of errors has been - just in
 so much do we approach
 nearer + nearer, to the
 absolute correctness of the
 result → & from Analogical
 reasoning we may justly
 conclude from this one series
 of facts that the assumed
 position is the correct one.

Are we desirous of
 avoiding the errors - instead
 of measuring them - we would
 in the case of H₂O Analysis -
 Make the retort as small
 as possible - & then saturate
 the H₂ with Oxygen.

Lecture 20thOxygen Comp.

We can calculate the amount of oxygen, that we are able to obtain from any - given amount of oxide - by a proportion of the Specif. gravity & the definite comb. by proportions.

There are also other substances from which we may obtain Oxygen - without so much heating, & in much larger Quantities - than with the Oxides. We, for this purpose, use the Chlorates - of the Alkalies - KOClO₃ - which are easily fusible, and by a slight heating give up all their oxygen, & afford by this means, an easy & profitable way for manufacturing Oxygen; this: - $KOClO_3 = KCl + O_2$

to prepare chemically pure
Oxygen in small quantities,
we make use of a small tube
with KOClO_3 - heat at both

Exp →

ends, + furnished at one
end with a small bulb,
by means of which

we may conveniently develop
the gas in sufficient quantities

When we have once used the
retort - be it large or small -
+ have allowed it to cool - then

The precau-
tions against
Explosion

are several precautions to be
used before we can safely
heat again. If we allow it
to cool as in Figure 1. that is -
by holding it still, and allow-

ing it to form
a thick crust;



Fig. 1

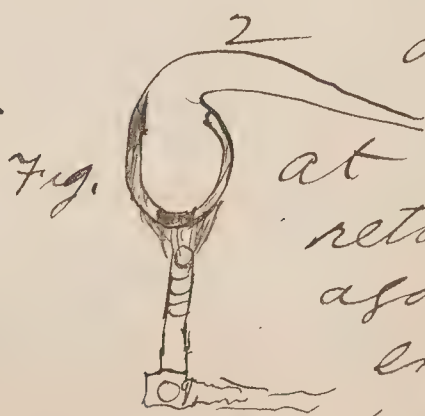


Fig. 2

a solid mass
at the bottom of the
retort when we heat
again - the gas gen-
erated in the imme-

diat contact of the flame, is con-
fined - + cannot break through
the thick solid mass - consequently

upon reasonable grounds - it must ^{Ditto} exert its expansive force upon the glass walls that confine it -

& when a sufficient amount - has been generated - this force becomes so great, as to shatter the glass with great violence - If however, we cool the bulb - by rotating it - we cool the liquid KClO_3 equally - in a thin film about the sides of the glass - & upon heating again the Oxygen (Fig. 2) can easily break through it, or melt it.

If KClO_3 be mixed with MnO_2

the gas may be generated at very low temperatures and with great regularity, the MnO_2 here acts as a contact substance - that is it undergoes no change & only acts by its presence (sand would do as well) - But, as is -

Danger with MnO_2

must always be the case - MnO_2 is impurified with Organic stuff or with Carbons, which give rise to more danger - from Explosions, than are to be feared from using KClO_3 without mixture; - So that the best plan is to use KClO_3 without admixture.

For generating large quantities
~~of large quantities~~ the use of
 KClO_3 - would be too expensive
 so that - we use a compound that
 comes somewhat abundant in
 nature. namely Pyrolusite -

MnO_2 $\text{MnO}_2 \rightarrow$ there are however so
 many organic substances con-
 posing part of the natural
 Pyrolusite that at first the
 gas is absolutely impure.

It gives up - not as the KClO_3
 all its Oxygen but only $\frac{1}{3}$ rd.

By heating with H_2SO_3 - we
 can procure from it - $\frac{1}{2}$ of its
 Oxygen.

From
 leaves
 of
Plants

There are many other ways of ob-
 taining gas - (not to be mentioned)
 If we place the green parts of
 plants - (leaves) - beneath a
 glass globe of water impregnated
 with CO_2 - & expose them to the

182.
Sun light - they will generate Oxygen
Oxygen - this method would however
be impracticable for manufacture.

Properties -

A colorless - transparent, tasteless
odorless gas - cannot have test
or smell or color - because of its
constant presence & action on the Organs.

It is incompressible as yet -
Specific gravity = 1.10561 -

With N it is mixed ~~with~~ in the
atmosphere - diffused - absorbed
in H₂O - in small quantities.
At ordinary temperatures, it
is totally unchangeable - but
at high temperatures it is Ozone
convertible into a, peculiar
body - possessing different
properties - from Oxygen, at
ordinary temps - This body will
occupy our attention in a
future lecture.

O

Is a vegetable coloring matter
it is - without action - being neither
acid nor base in property.

It is called Oxygen because
of the acid nature of its compounds
with the metalloids.

It has the property of bleaching -
like Chlorine but very
much slower. but the stuff
must be moistened & we must
have light. (bleaching).

By CaO, H.O it is not rendered
turbid -

We shall now combine O with
various other Elements & also
see the phenomena attending them.

1st Carbon - at ordinary tem-
perature no change - but upon
heating - a combination attend-
ed with light & heat. The com-
bination - that results - is tested.
The resulting compound is a comb. of
C + O - we call it Carbonic
Acid. It is a gas - & we prove

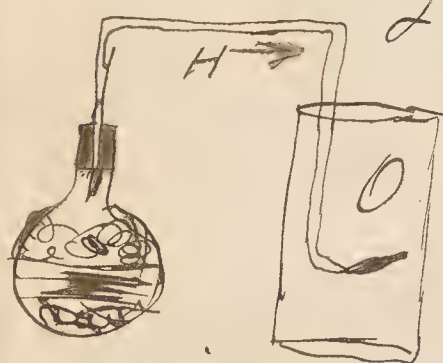
ExpC
andO

its acid properties by bringing ¹²⁴ it into contact with litmus paper. O
It renders CaOH turbid.

We call the temperature at which we must heat the body to combine with Oxygen - the ^{Combining} ~~Burning~~ point - the point at which combustion takes place. Combining temperature. Combustion

We observed no flame with Carbon but only a brilliant glowing.

2nd. Hydrogen - If we lead H. H
into Oxygen - no combustion takes O
place - by Heating sufficiently



& then plunging the gas stream into a jar of oxygen, the combustion takes place energetically -

The resulting compound - here forms a liquid deposit upon the sides of the vessel - when analyzed it is found to be pure water (H_2O) H₂O

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C+H
with

O

Exp3.rd Wood - (composed of C.H + Owhere heated combines with O_2 to

form of Course Carbonic acid

 $CO_2 + H_2O$ - test the resultantwith CaO + shows precipitate of $CaCO_3$

4th Sulphur - at ordinary temperatures no result - but by heating to 150° it burns (combines) with a fine blue flame - the resulting compound is an acid - SO_2

Tested by litmus paper -

P

and

O

ExpPhosphorous → at ordinary

temperatures - no result - but

by gentle heat - the combination

is brought about attended with

intense light + heat - the resulting

Compound is again an acid -

mixed - P_2O_3 + P_2O_5 - the affinity

is so great that a combination

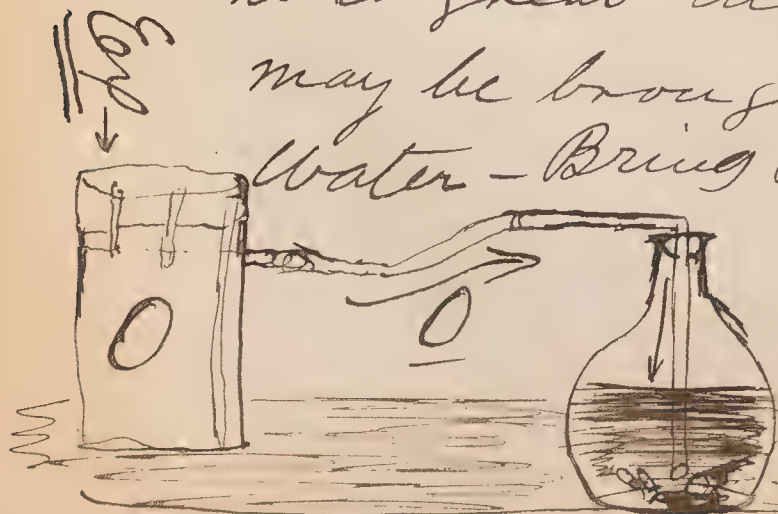
may be brought about under

water - Bring P. into HOT water - to

melt it - + lead O

upon it - the result

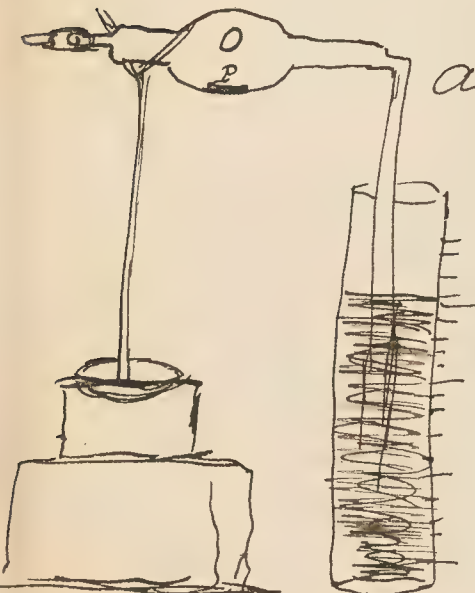
will be a Combustion under water.



Lecture 21st

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To prove the fact that the phenomena we have observed - are really chemical compounds!



By bringing a weighed amount of Phosphorous into contact with a measured amount by volume of Oxygen. Measure the volume before and after - ~~the~~ the loss of volume - on cooling - gives is the amount of Oxygen which has disappeared. The 2 Measurements must of course be made at the same temperature & pressure \rightarrow if not they must be both reduced to 0°C + 760 mm.

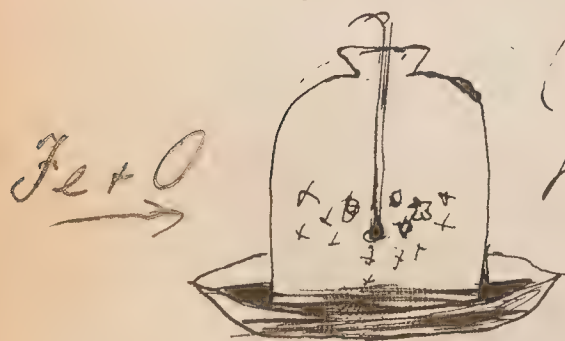
By this simple means we can carry out a clear proof of Chem.

ical combination.

Compts. If we have weighed the bulb before the operation & then again after it - we would have a contrall over our analyses - & we should find that - just in so much the increase in the weight of the bulb had been just in so much had the weight of the Oxygen volume diminished.

Ex Make a similar analysis of $As + O_2$ with the same arrangement of apparatus.

Iron with Oxygen.



(Combustion has been so highly intense that particles of the product of combustion have been driven into the solid plate beneath a mass of water.)

Magnesium + Oxygen \rightarrow carry
out the analysis similarly. Mg+O

The Magnesium wire dare
not come in contact with the
slap - for so high is the temp-
erature of combustion - bet-
ween the Elements - that the
wire & slap would have melted
together and, by this means,
part of the wire, unconsumed.

He must therefore arrange it
so that only a very small
point of the wire, beaten out
fine for the purpose - shall
touch the slap - while the rest
is removed from contact of the
glass. He must also choose the
wire very thin - for the more
metal used the fiercer the heat
derived from the combustion - will
be, & the greater the danger to the glass.

Lecture 22nd

Na + O. Combine Na with O - to show the color of the light emitted.

It is time to discuss the laws by which these various phenomena of chemical combination are brought about.

We call this burning of bodies in Oxygen - an Oxidation - The compound we call product of Oxidation (oxide) - may be acid or base.

Explana- Where do we get the tremendous
tion of the heat by which is almost
Evolution in every case set free - by
of Heat chemical combination?

by We have seen that in uniting
Chemical Oxygen with Hydrogen - for
Combini Example - the resulting com-
pound was a liquid - H_2O
But from Physical laws, we

Know that, the conversion of Ditto
 a gaseous body to a liquid state,
 is attended by an evolution of
 latent heat - necessary to hold the
 body in its gaseous state. So that
 the Question naturally arises - Is
 not this the Cause of the heat of
 Chem. Combustion? By a farther exam-
 ination we are forced to admit that
 it is not; for when we combine other
 elements - Carbon for example with O.
 the change is from a Solid (C) to
 that of the Gas (CO₂) - Here the
 change in physical condition is the
 Contrary of the previous example, &
 we should - were the hypothesis true -
 expect to see in this case - heat ab-
 sorbed - or what is the same - Cold
 produced: but the same phenomenon
 of intense heat - accompanies this Comb.
 So that this is not the true explanation.

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Sill's - We explain it as follows →

We know that when a body - as for example - a Meteorite falling upon the earth loses its motion suddenly & generates an equivalent amt of Heat. So the atoms - are when brought into the neighborhood of one another - attracted to one another - & set in motion -

when they have combined - the motion ^{produced} ceases & an equivalent amt of Heat is

Heat by
Combinat.
How
determin-
ed

To determine the amount of heat set free by a chemical combination we enclose the substances to be combined in a vessel → surround this, with a layer of ice → about which we place a vessel of the same material, the amount of ice melted gives us a standard by which to compare → the amt of Heat generated by different Combin.

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The amount of heat set free by chemical combination - is dependent;

1st Upon the Chemical nature of the substances combined.

2nd Upon the absolute temperature.

3rd Upon the physical condition of the combining bodies - (Carbon as (Diamond - Graphite & Charcoal - gives different degrees of heat by combination with O.)

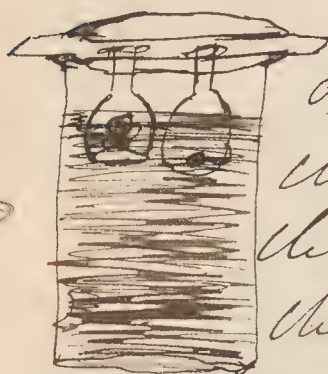
The temperature of Combustion is dependent upon

1st Upon the Chemical nature of the body. (Phosph. + Sulph.) Exp.

2nd Upon the physical (allotropic condition) of the body. Phosphorus as ordinary, & red Phosphorus) Exp.

3rd Upon the presence of a third body. Phosphorus Exp.

in two flasks - in the one allow
some vapour of Turpentine to enter



Place both in ~~hot~~ water
and it will be observed that
the flask which contains
the turpentine will ignite
the other, on the contrary - will not.

Phenomena of Light by combination -

Flame is nought but a volume
of glowing gas.

The first thing about the temp-
erature demanded for the comb-
ination of the gases with O →



The Heat necessary for carrying
on the combination is then fur-
nished by the Combustion itself.
(see heat by combinations)

The particles of the gas as they
escape - fine, by the pressure upon
them of those behind, the upright
form to the flame - & in cases

where there is no pressure \rightarrow the Ducts
 burning particles - being specif-
 ically lighter than air would
 rise, & condition the position of the
 flame. As the particles rise higher
 & higher \rightarrow they are gradually cooled
 by contact with the cooler air \rightarrow
 a point is at length reached where
 the gases cease to be luminous;
 this fact explains to us, the con-
ical form of a flame.

Those substances which do not give
gaseous products of combustion
 do not give us a flame, but only
 emit light - (incandescence).

Iron f. ex. gives us Fe_2O_3 . Those
solids which give us gaseous
 products give us more or less
flame - Sulphur - Phosphorus.

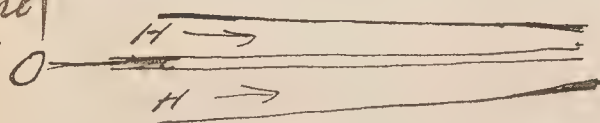
Carbon - the latter, appears to
 only glow - but a small flame exists.

Lecture 23rd

The combustion of substances in the air - never gives us the total amount of heat from the combustion, which we can only obtain by burning the body in O. On account of the presence of Cald Nitrogen - to which a great amount of heat is given off.

By burning substances, then in Oxygen gas - we are enabled to preserve a vast amount of the heat of Combustion

Oxy-H₂ -
hydrogen
Blow pipe
Exp



By an arrange-
ment like the

one represented here - namely. By leading a stream of Hydrogen gas through a tube - and within the tube a yet smaller tube of Oxygen. we can bring about so intense a

a flame that - the most infusible substances may be fused.

Exp → Platinum fused. Fe - burned.

Sb - volatilized - This ditto → and Expts the same combustions can be effected by $C_2H_2 + O$.

Phenomenon of Light.

Is this phenom. an accompaniment of the act of chemical union? → or
Does it show itself after the action has ceased? Question answered hereafter more fully -

It is proven that the given out of light is independent of the action of Chemical Combination.

And - each element has the property of giving out, at certain temperatures, only certain kinds of light - Sodium - for example, when brought into the flame Exp as NaCl - when the temperature is

sufficiently high gives the yellow.

Independ. flame. So will NaO. So will NaCl.
 of + so will any of the compounds of Na.
 Chemical the only condition required: being
 Action the elevation of the temperature to
Exp a sufficient degree. Show this
 fact by the flame of Na. of NaO
 of NaCl + other compounds.

Show its power of converting the
 red of Hg I to yellow. & by this
 means prove its special property.
 These facts are sufficient to prove
 that the property of giving out
 light of various kinds is indep. of. C. Comb.

So that when substances are heated
 to certain temperatures, we have
 all the conditions necessary to
 produce the phenomena of light.

Spectrum The different kinds of light
 +
Colors differ from each other only in
 the rapidity of the vibrations they

passes. So that by a prism we are enabled to refract them at different angles + place them side by side.

It has been shown by Prof. Kirchhoff - that a certain ratio - a certain relation exists between the absorption + emission of light - namely - that - it is a constant one.

The more transparent a body, is the less - light will - for a certain temperature be emitted - Gases - for example - are generally transparent - they absorb very little light - + hence they emit very little

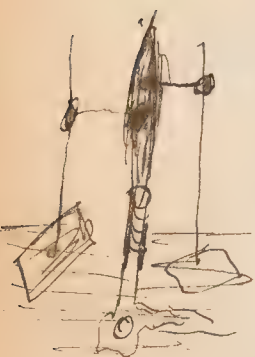
H + O burn with an almost invisible flame. A piece of Platinum + a bead of Copper NaO RO₂ ^{are} - placed side by side

in the non-luminous flame - emit light very differently. The first is opaque - it absorbs much light + emits a large quantity cor -

¹³⁹
responding. The NaOPO_5 head,
on the contrary, is transparent
it emits very little light because
being transparent it absorbs
none. And the two substances
in the flame appear very signi-
fically - the Platinum a brilliant
white spot - & the head of NaO ,
 PO_5 by its side - appearing in
contrast almost black.

This explains to us why when
two gases are combined there
is no or very little light emitted
O & H for example - burn
with almost no flame light
both the gases & the product of
combustion being transparent.
If, however, we place in the flame
a solid \rightarrow CaO - for example -
the most brilliant light is
brought about.

Ditto



CaO
light
Ex

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The amount & kind of light which a body gives out, depends upon the temperature. If we heat a body slightly it gives out - one kind of light upon increasing the temperature, however, the light changes - very frequently - in proportion.

If we heat solid & liquid bodies we find with almost no exception they give out all kinds of light - But gases when heated do not give out all kinds of light but ~~to~~ exclusively one or two, &c, kinds of light - By heating Iron - for example - we get first

Red light - by increasing the temp. Example

R	O	Y	G	B	I	V	
---	---	---	---	---	---	---	--

erature we obtain R & O, still, further, green - & finally - we get light of all the col-

ors mixed - or White light.

With gases, this is not the case -
 for they possess the peculiarity
 of giving out (emitting) certain
 kinds of light. If - then we
 pass the light emitted from va-
 rious bodies through a prism,
 we can note these peculiarities
 with the greatest sharpness -
 & no method of analysis is so
 accurate & so safe for the mi-
 nutest quantities than this.
Spectral Analysis - Solid bo-
 dies will give us a continuous
 spectrum of all the colors -
 Gaseous ones - on the contrary
 can only emit one or more
 kinds of light & hence give
 us bright bands in place
 of the continuous spectrum
 of solid bodies.

If we place volatile bodies, Do
 for example - the salts of the al-
 kalies or of the Alkaline Earths - in
 the flame - we can with the eye Exp
 unassisted - see the most various
 colors shown by the different Bases
 Place side by side - salts of
 BaO , SrO , NaO , KO , as an il-
 lustration.

To return to oxygen \rightarrow
 we have the questions yet to
 answer, How does one proceed How
 to form Oxides? to form

(1) We have seen that by burn- Oxides
 ing the Element whose com-
 bination we desire to ob-
 tain, - we can bring
 about this result.

(2) By bringing the body into
 contact with some sub-
 stance which is rich in

Ditto

Oxygen - & can be made to part with it easily. We obtain likewise an Oxide.

Substances which part thus with their Oxygen - are termed Oxidizing Agents, and for Agent!

the production of oxides - in the laboratory they are always used, in preference to the first method. Such bodies are numerous. HgO -

HgO the body before used to manufacture Oxygen - by heating breaks up into $Hg + O$ & the latter combines with the substance to be oxidized, the former, volatilizes, & is gotten rid of. On account of this volatility this substance is much used for Oxidizing purposes in the laboratory.

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NO_2 - (concentrated - or dilute) Ditto
possesses this property in a
high degree: & its resultant
product being volatile, it is
generally to be preferred to
 H_2O ; on account of its Cheap-
ness & energetic action.

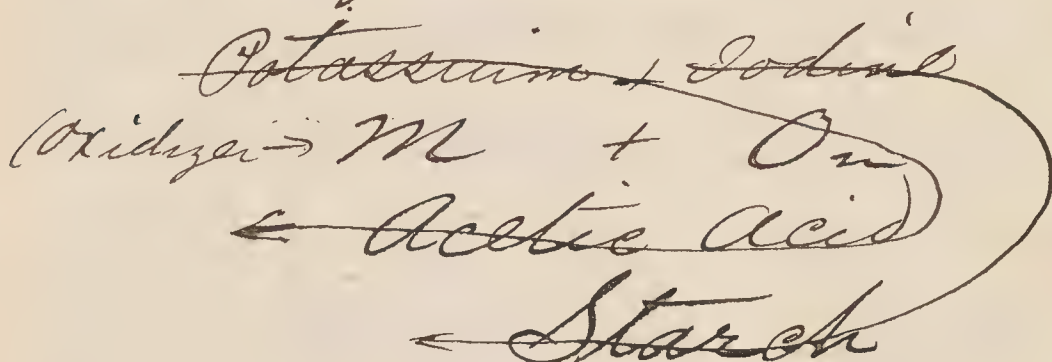
Show the oxidation of Iron - Exp
of Fe &c by NO_2 (fuming).

Chlorates & Nitrates are oxida-
ting agents - & often used -

Chlorine is a very powerful
Oxidizer, & frequently used.

It often becomes a question
of importance to know whether
or a substance is an oxidi-
zing agent or not. For this ques-
tion we have an unfailing an-
swer, in the use of a test which
is unsurpassed for its delicacy
& rapidity of action.

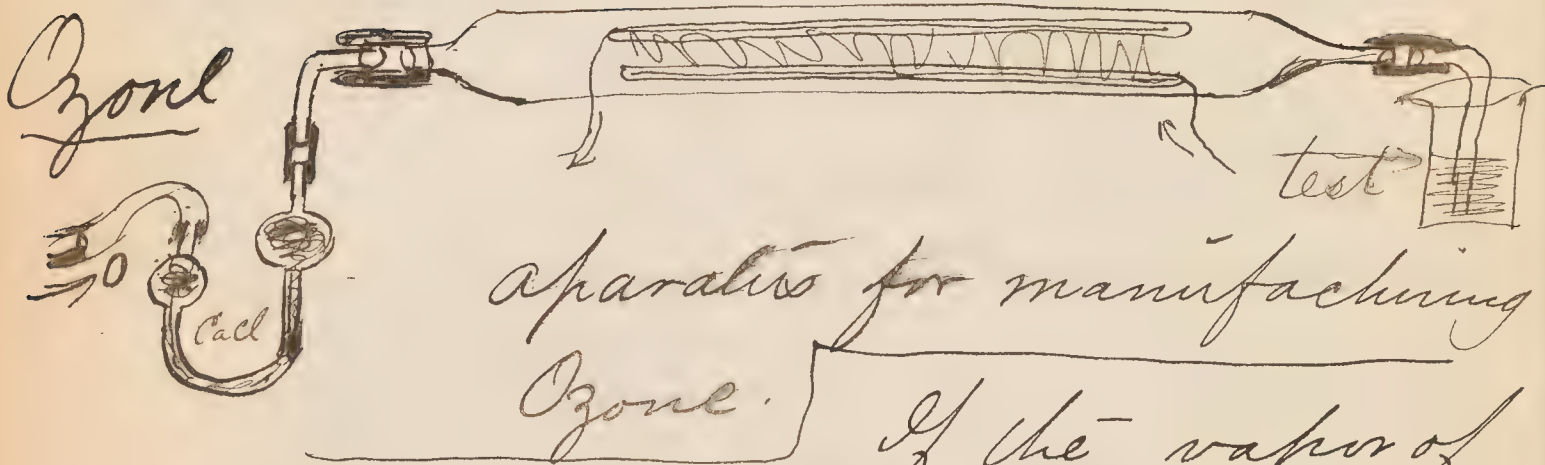
How to de- We have only to take a solu-
 ted the tion of K I (Iodide of Potassium)
 Presence Bring into it some Starch &
 of an some Acetic Acid. If then -
Oxidizer we bring into this solution
 an oxidizing agent a
 blue coloring at once appears
 caused by a precipitate of
 Iodide of Starch. Thus.



Forms.

Acetate of Potassa +
 Iodide of Starch (blue)

The Potassa ^{juv} seizes upon the
 Oxygen - combines then as
 KO - with the Acetic acid
 while the free I - combines with
 Starch - forming a blue precipitate

Lecture 24th

If the vapor of water be present - oxidation may take place, at low temperature. The vapor of H_2O acts according to the 3rd law, that gives to the third body the power of acting by its presence.

Slow

Combustion - This is the phenomenon, which we always & constantly observe when - metallic substances - Iron, Cu etc, are exposed for any time to the air; the usual name for the phenomenon - is rusting - The resulting substance is no longer Iron or Cu but an Oxide of these metals.

This combustion is unattended Ditto.
 by an evolution of light &
 heat: because the combina-
 tion takes place so infinitely
 slow that the very small amount
 of heat generated in a measurable
 time is inappreciable. This same Decompo-
slow Combustion - removes from surface
 the earth's surface & converts Organisms
 into useful combinations - the
 millions of animal & vegetable
 remains: which otherwise — Chalk.
 would, by their multiplication soon
 remove all the ingredients for
 their nourishment & propagation
 of ~~all~~ organic life. The soft
 parts are quickly decomposed -
 converted into NH_4O , $\text{CO}_2 + \text{H}_2\text{O}$; the
 hard parts bones - shells &c, last longer
 & are slowly, very slowly carried away
 by the H_2O in solution.

The life process of animals is
 Respira- not just but a chemical one,
 tion of The useless particles of the body - com-
Animals posed of $C + H$ - are consumed in
 the Capillaries. & carried away

Ex.

from the body through the lungs - in
 the form of $CO_2 + H_2O$ - while new O enters
 to keep up the combustion & animal heat

Reducing If we wish to take from
 Agents, the oxidized body, the oxygen
 which we have just given it;
 we must use a substance
 of opposite properties from an Oxidiz-
 ing. We need a substance which
 having little or no Oxygen - has
H. a great affinity for it, & which
 will seize upon it upon all
C. favorable opportunities

Such bodies are numerous -
Hydrogen + Carbon are the
 most excellent.

Exceedingly active oxygen \rightarrow Ozone.
 At ordinary temperatures, it
 is capable of bringing about
 combinations which can only be
 accomplished by Ordinary O at high
 temperatures. If we bring or-
 dinary Oxygen into contact
 with our test for oxidizing
 agents - we will find no blue-
 ing. But with Ozone, we will
 get an instantaneous ^{coloring} ~~flame~~.

If we burn H gas in
 a flask, over our test for oxidizers
 we find that our oxygen -
 that is uncombined - has ab- es
 tained the power of oxidizing -
 or, it has been converted into
 Ozone. Explained \rightarrow By the
 increase suddenly of the temp-
 erature + the sudden cooling off
 of air we form Active Oxygen.

Manuf. 157
active

The best method of performing this sudden rise + fall of temperature is by means of the Battery - + use the apparatus on page.

The tubes of glass are shown only 2 in number on the figure there are in reality 12 which accomplish an increase in surface

Ex. Perform the manufacture + show the bluing of the test.

The allotropic O has a peculiar smell of Cl. very strong + unpleasant - accompanies the

Properties. action of an electrical machine - or lightning.

Oxidizes Ag. at ordinary temperature - Bleaches Indigo - like Cl. MnO-salts - precipitate

Ex

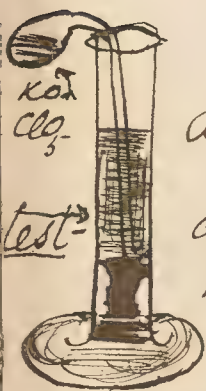
MnO₂ by leading through
The highest oxidations are brought

Generally - Platinum under Water - is oxidized - which Ordinary O will under no circumstances do. Brought into contact with Organic substances they are rapidly oxidized.

A very small quantity of Ozone is produced by every manufacture, of Ordinary afO - which is accompanied by heating - Exp

With $KOClO_3$ - the test is blue on heating + forming Oxygen (+ Ozone).

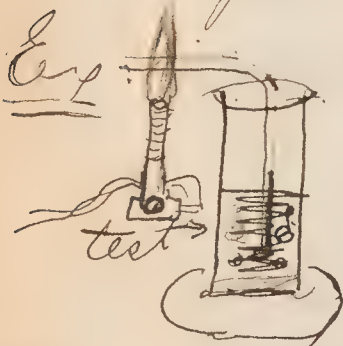
With H_2O + K_2CrO_3 - it is brought about sooner. In the presence of a free alkali no Ozone is formed - not a trace.



So that if we wish an O free from active O - we Note have only to place a free alkali in contact with the manufacturing substance.

Lecture 25th

Ozone if we heat this ozone to 100° we can destroy it as ozone & procure again Oxygen (ord)



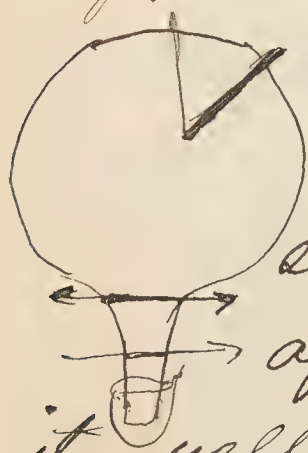
By heating the gas after it has passed the electrical ordeal, before entering the test, we will find that it has lost the power of oxidizing the test, by cooling off it will be oxidized as before. The amount of O that is altered into this Ozone is only $\frac{1}{100}$ part of the volume of the Oxygen - 2 or 3 per cent is all that at one time can be so altered.

Proof

By leading the gas through two cylinders of the test - only the test of the first cylinder will be affected, that of the second remains unaltered.

Exp

What is the reason assigned for this singular Oxygen called. Sp. Ozone. It was attempted to determine the spec. gravity of the Ozone, but as only 2 or 3 per cent. of the whole amount of gas is Ozone, there is a corresponding diff. It was found that the sp. grav. was 3.3; almost 3 times as great as Sp. Gr. that of ordinary Oxygen - that is - the Ozone is a condensed Oxygen.



The fact of the condensation, is proven, by passing a stream through a jar of O - & after cooling - it will be found to have contracted its volume. proven by placing the jar under H₂O - The experiment may likewise be reversed.

Exp

Q. itto.

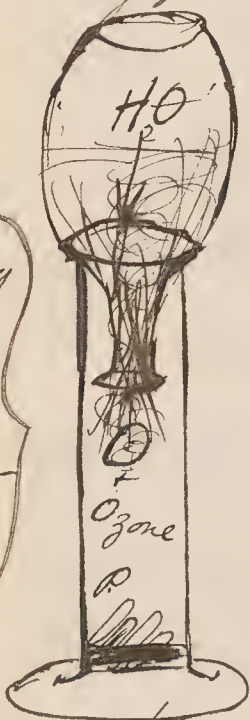
Plays a singular role in the organic + inorganic world.

slowly oxidize organic + inorganic bodies slowly - Phosphorus.

for example - a small part of the Oxygen in the neighborhood is converted into allotropic Oxygen. Show - by testing.

Ex

(Collecting Gas by Displacement)



It is a good fortune that this Oxygen does not convert itself so easily into Ozone - for were much of it in the atmosphere it would not be adapted to organic life - as it acts like Chlorine upon

Organic tissues, destroying them. Caoutchouc - one of the most impervious substances to chemical action - is eaten in a short time through + through.

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In the Atmosphere there is always a small quantity - & it is supposable that its amount stands in close relation with the health of organic beings - (Epidemics &c).

This Ozone proves a singular fact, namely -

That one & the same body chemically - may assume, several peculiar conditions -

We call these abnormal conditions - Allotropic.

Nomenclature

It is founded chiefly upon the Compounds of Oxygen, as they are by far the most abundant - & important. The one principle of classification continues to hold throughout the whole domain of Chemistry.

Before the present nomenclature, all kinds of odd & fanciful Pharma-names derived from the Alchemical & mist were in vogue for Chemical Compds. many are yet names held in Pharmacop. Sal mirabile Glauberis

We have it in our power to give a name to all the possible compounds that can be formed. Lavoisier has the credit of founding the nomenclature. Those compounds which are not acids may be divided into 3 classes. Metals + Oxygen

Nomen. of Oxygen Compds

- 1) Oxides → (which Comb. with acids.)
There may be, however, several Oxides - both distinct proportions so that we distinguish between Prot oxides - Bi oxides. Sesqui Oxides, (~~Per-Oxides~~)
- 2) Those Compds - (not acids)

which have not the capacity of Nomenclature combining with acids. Oxygen Sub-Oxides. Compds

3rd) Those which have the power of combining with acids - but contain more Oxygen than the simple bases (1st) - Super-Oxides.

Acids - Metalloids + Oxygen

To the compound which forms with acids the most characteristic & compounds, we give the name - & termination ic - the lower & higher Oxides we form by alterations

Hyposulphurous Acid

Sulphurous "

Sulphuric "

The higher compd if it existed would be Hyper sulphuric Acid
H. &c.

Lecture 26th

We can unite acid & base & - our nomenclature then is as follows.

a union of Sulphuric acid for examp. is a Sulphate of an Oxide - Sulphate of Magnesia for ex. Chlorate of Potassa &c

but in this case - as with binary

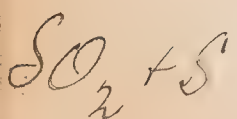
Neutral compounds we must distinguish Acid between various kinds of salt,

+ these acids bound with 1. or
Basic 2 or 3 or ∞ equivalents of the
Salts base - &c. So that we have
 Acid - Neutral & Basic salts
 to distinguish in the cate-

gory —————

Metals combined with sulphur
 we call Sulphides. (analogous to
 Oxide - Chloride &c). Those metallic Oxides
 combined with SO_2 we call Sulphites.

Metals
 with



We only use the names of the Elements - & by their combinations can make every compound.

Salts may combine with salts to form a Quaternary - then Double we merely set together the Salt names of both. $KCl, PtCl_2 =$ Double Chloride of Plat. & Potassium & Ammonia. Muriaic Acid.

Salt peter - spirit of wine, Old Names
H & C.

Laws of Chemical Comb.

The foundations of the science of Chemistry; constantly used, I deduct them from Analyses.

1st Law. The law of Constant or definite proportions.

Every analysis of HgO - at any time will give us the same proportion of $Hg + O$. So that if we Law 1.

have made 1 Analysis of a substance correctly, it is a valid one for the substance at all times & places, We generally express the composition of any analysis in per-cents - as more convenient.

It is possible that besides this compound another may be brought

Says about, we find that thus in most
of cases can be done - but all
Multiple these variations are found to be
Proportions simple & multiples of the first
many

Compound. 1st - ^{may} be a Compound
containing 1 part of O with 1 part
of a Metal - we may have then
a comp'd of 1 pt. of O with 2
of Metal - or what is generally the
case. O + metalloïd - we may have
1 O to 1 metalloïd.)

2 11 u u u
3 u u u u
4 u u u u

Compare
with
numbers
from
parents

We can now reduce our numbers to a unity - for we can answer the question - How many parts of a body combines with 1 part of Oxygen (or 100 parts)?

The table showing these re- Illust. sults - are upon the board

More convenient to reduce the same numbers to the amount of substances - which combine with 1 part of Hydrogen.

These numbers have received names of various names \Rightarrow Chem. Differ- ^{of} theseentials - Atomic, Equivalent Weights numbers Combining numbers. &c. &c.

They are of the utmost impor- Relation tance for they stand in the most between intimate relation to the physical ^{these num-} bers + the properties of the bodies invol- Sp. Gr. ved. Specific Gravity - + the

Specific Heat. (Explains) Sp. Heat
~~bring this page before law 2nd~~

This law enables us to decide by an analysis whether a substance is or is not a compound or a mechanical proption. We can tell also what compounds are possible & what are impossible.

The law of the Relation of Equivalents -
3rd Law. elements among themselves.

These numbers, these Equivalents, express not only how much of Sulphur, or of Phosphorus, or of Iron, (for example) - will combine with 100 parts of Oxygen - (or with 1 part of Hydrogen) - but they also express the proportions by weight in which these various Elements combine with themselves, (Illustrate.), which combinations likewise follow the law of

Illustrate

Ref

Multiple proportions -

16 parts of Sulphur combine
with 8 parts of O -

With 16 parts of O,

2 24 4 4 4 &c. &c.

Lecture 27thLaws of Chemical Comb. (con)

Between the chemical Elements and the compounds there is no real difference. \rightarrow 4th law depends upon it.

4th Law
 Compounded bodies combine with one another in fixed definite proportions. just as the simples. \rightarrow or in multiples of some definite quantity. - & the atomic weight of the resulting compound - is nothing more or less than the sum of the atomic weights of the separate elements composing it. Compounds of the same quality come up here as with the elements. 1 to 1, or 1 to 2. or of 2 to 3 &c

Most chemists compare their
Equivalents upon Hydrogen
as a unit, on acct of the
simplicity of the numbers.

Accordingly, when referring to ^{Derivation} of
the relative amts of the various
Elements, that will take the places of Equivalent
one another in Comb. we call them
Equivalent quantities. Hence, ^(the words) Chem. Equiv.

For convenience & labor
saving - we use the first let-
ters of the names of the combi-
ning elements - & we under- Abbr.
stand thereby - not only the relations
elements but also the rela-
tive value of the equivalent - of
the element that we abbreviate,
so that we express at once, the
Elements - & their proportions
by weight - as they exist in
a combination.

If the compound is not one of 1 to 1. we place the multiple beneath as an exponent, thus $\text{FeO}, \text{SO}_3, \text{Fe}_2\text{O}_3, 3\text{SO}_3$ &c.

We can also by these ~~for~~ letters the method in which, or

Reac. tions by which various bodies are formed - decomposition is brought about &c, we call these expressions; Reactions.

Sulphuric acid is = SO_3 .

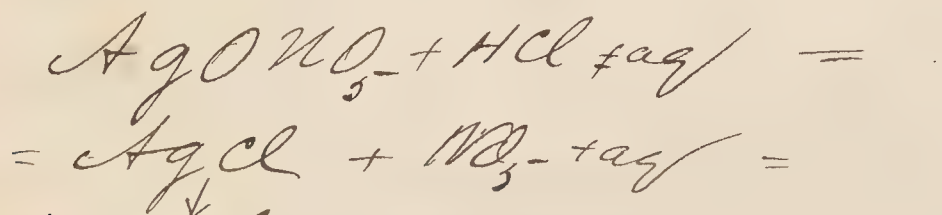
Potassa ——— " = HO

Empir - They combine + we assume equal & that a particle which we call Rational (HO) unites with another which Formulas we call SO_3 because by decomposition we can separate both $\text{HO} + \text{SO}_3$ as Proximate Constituents. We do not know how the particles of K. S \& O are positioned in the compound.

We only know that the abso. Ditto
 lute expression of that comp'd,
 is — K, S, O_4 . Such a for-
 mula - which expresses only
 the quantity & the elements that
 are combined without attempting
 anything ^{about} their mutual position of
 the particles is called an Empirical Formula.

One (as KO, SO_3 (with prop. constituents) that
 that does attempt it, is a Rational Ditto.

Elucidate the expression of
 a chemical decomposition, Illus.
 by a reaction.



As, by no human agency - can
 matter be lost or gained the
 quantities in their sum - upon
 both sides of this equation
 must be absolutely equal,
 to one another.

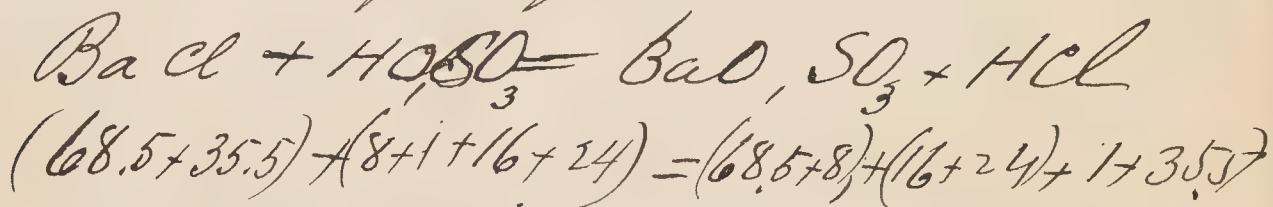
$$169 \quad (39.2+8)+(35.5+40) = (39.2+35.5)+48$$

Ditto



$$(47.2 + 75.5) = 122.7 = (74.7 + 48) = 122.7$$

That is - the atomic weights of both sides of the equation must be equal to each other, else the conditions of a chemical compound or decomposition are not fulfilled.



$$(68.5+35.5)+(8+1+16+24) = (68.5+8)+(16+24)+1+35.5$$

If the additions are made the amounts will be found to be equal upon both sides.

We have now followed Atomic out by practical illustrations Theory. all the great laws of Chemical Combination, and we must now advance to the suppositions - which have been made with the idea of explain-

ing their cause. (It is better alto
 in Nat. Science, to fix firmly
 first of all the facts, the laws
 & then proceed to the hypotheses
 which attempt to account for
 them). Why then; - do the
 Chemical Elements Combine al-
 ways in fixed & definite propor-
 tions, never varying in weight.
 so that when a compound is
Once analyzed, it suffices? Why
 when we know the Equivalent
 amount of Oxygen that will
 combine with a body - do we
 know the equivalents of all
 the other Elem. that can pos-
 sibly combine with it? Why
 does nature make these great
 leaps between compds. & allow
 only of compds in multiple
 proportions? To answer all

Dilts

definitely & satisfactorily Chem-
ists have adopted a simple
theory - which answers them
all. It is, that there are ul-
timate particles to matter of all
kinds, beyond which division
is impossible - (hence, these
ultimate particles must be
infinitely small), & that it is
these ultimate particles that
combine, with other ultimate
of other Elements - in proportions
of 1 to 1 or, 1 to 2, or, of 2 to 3, &c, &c,
farther! - that these ultim-

Atoms

ate particles are equally
large - and lastly - that
the weights of these ultim-
ate particles are different
for each Element - and that
the weights (relatively) of these
ultimate particles - or

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Atoms is nothing more, ~~or~~
less than those numbers which (Dilts.
we have called Equivalent
Numbers - Combining Num-
bers &c.

An Atom of Oxygen weighs 8 times
as much as an atom of H.

An Atom of Sulphur 16 times.

" " " Chlorine 35.5 "

&c. Which shows us why it
is impossible to have com-
pounds in all possible pro-
portions by weight. for-
an atom cannot combine
with $\frac{9}{10}$ or $\frac{8}{9}$ or $\frac{7}{10}$ &c &c of another,
because their ultimate par-

ticles are from their name in-

capable of subdivision - so

that 1 atom must always combine

with 1 atom - or with 2 or 3 &c

that is in some rational quantity.

Lecture 28th

Atom a combines with a & b . etc. - this

Mult.

$$(a + b)$$

Prop.

$$\text{or } (a + b) + b$$

" $((a + b) + b) + b$ always a multiple of the first compound.

The Law of the Equivalent Sum follows also as a natural consequence.

This Hypothesis has much in favor of it, for it gives us a rational & satisfactory explanation for our chemical laws.

Atom
Combines
with a
Homog.
neous

Not only heterogeneous particles can unite with each other - but apparently homogeneous diths. For we have seen that (ozone)

Atom?

Allotropic Oxygen - is a combination in some way of three Oxygen atoms condensed to 1.

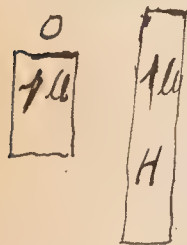
Between these Atomic Weights Relations
 + other physical properties of bet-
 matter there exist some re- Atomic
 markable relations - vide: Weights
 8

1st There is a singular relation
 between the Specific Heat, + Sp. Ht.
 these Atomic Weights.

Explain Specif. Heat. - If we
~~heat two atoms~~ ^{have} equal weights
 of two or more elements at
 the same temperature. + wish
 to heat both these bodies to another
 temp. very unequal amounts
 of Heat, will be required. - a
 definition, then, of Sp. Heat. is - that
 it is for each body, the amount
 of Heat, which a unit of weight
 of each - requires - in order to
 raise its temperature - from
 0° to 100° Centigrade - or from
 0° C. to 1° C.

Now - if we multiply these various Sp. Heats - with the Atomic Weights we always become the same quantity - (Illustrate). Or - Multiples of this quantity.

Illus



This regularity shows us that - one & the same quantity of heat, only, is necessary to raise an atom of any element ^{through} to the same number of degrees of temp. - The formula is as follows.

1 lb. Se. requires at. wght - 39.6 : x &c for others. (Tables in Inorganic Chemistry)

Ambiguity How can we tell whether we have the atomic weight of an element - or a multiple of its Equivalent? For, some of these numbers are the double of others: & to bring about harmony

we would be obliged to multiply one row of numbers (Equivalents) by 2 (or - vice versa) to divide another row by 2 to make the specific Heats the same. And some Chemists do this very thing namely - multiply the larger row of atomic Weights by 2. There are other laws which object to this proceeding. *zum Beispiel.* Faraday's Electrolytic Law. Depends upon the quantity of Electricity which is necessary to separate an atom of a Comp'd - from this Comp'd; different Elements require different amounts of Electricity. If we measure this amount of Electricity for each atom Substance - & then proceed as with the Specific Heat - that is multiply these amounts with the

Atomic Weights of the betref-
fenden Körper we become
the same quantity. or a mul-
tipl of it. That is the quantity
of electricity which the atoms
of each Element require to
be separated from a com-

A Contra-
dition - pound is one + the same.
But here again we have
multiples - + if we divide
or multiply - in the case of both
these laws (of Sp. Heat + Electricity)
we find that the atomic weights
which we obtain. do not agree
with one another. but are
multiples. So that. there is not
as yet a means in our pow-
er to determine absolutely
what is an atomic weight.
Many chemists have by
looking at these results in

different lights adopted one series of numbers - others again, another - but all *Equiva-*
 these changes make much little
 confusion - & there is really
 no advance made in a
 Scientific view. unless some
 sure means is placed in our
 hands for determining abso-
 lutely what is - & what is not
 an Atomic Weight. Until this
 is attained, it is by far the best
 to hold by the Old Numbers, which
 indicate to us - the Equivalent
 amounts of the various Elements
 which represent each other
 in Chemical compounds & decom-
 positions - they have the ad-
 vantage of precedence -
 while nothing is absolutely
 gained by using the others.

Lecture 29th

3rd Ueta. There exists a singular re-
lation between the form in
 which a body crystallizes and
 the chemical constitution of
 it. A relation first pointed
 out by Mitscherlich & which
 since his time has become of
 the greatest importance, not
 only in drawing the bond
 that unite Physics & Chemis-
 try, but more closely - but
isomorphism in enabling us to infer
 with much security upon
 the real Atomic Weights of
 Elements & Compounds. So that
 this phenomenon, a descrip-
 tion of which shall follow -
 gives us a third - means to
 determine true Atomic Weights
 It is as follows: —

Analogously constituted bodies - with reference to their atomic condition; crystallize in the same form, or in very similar forms of the same system, with the same or nearly the same angles of the crystal surfaces. This peculiarity is called isomorphism - & the bodies isomorphous.

Many bases - composed of metallic Oxides of the same general character. (MnO , FeO , NiO , CoO , ZnO &c) can supply the place of one another in combinations with the same acid, and acids too, of the same generic character SiO_3 . SeO_3 &c can represent one another in compounds - & all the various salts, be crystallized in the same, or very similar forms. Need only mention the Alum-group. Spinell Group. Sulphates (Rhombic) with Calcium &c &c.

Explain We may often meet apparent
 lion of Contradictions to this law of
 Contradiction. Isomorphy - where ² anal-
ogous to Isom. of grossly Constituted bodies -
 crystallize differently - For

all the crystalline forms of ~~both~~
 both may be unknown to us -

We may know for Exam. only one
 form of each - which may be differ-

I. II
 & &
 b. a ← Illustration, we find an Explanation.

This isomorphy gives us a means

applic. to determine the probable great-

ness of the atomic weight, for

At. Wght if we have decided the atomic
 constitution of one compound &
 its atomic weight - we have

an Anhaltspunkt - from

which to decide the true weight
 of other members of the group.

The same contradiction takes place here as with the other two laws - (of Sp. Heat + Elec. Deconv.).

We can never say that this is or that that is - the true Atomic Weight of a body.

It is - 1st The Nature of the Atom
2nd the Number of those atoms, +

3rd the Manner in which those

atoms are positioned in the

Compound - which determine

the nature (chemical) of the

Comp'd. Bodies may be

composed of the same atoms

the same number of ditto - Isomers

but show entirely different

chemical ~~and~~ character - but

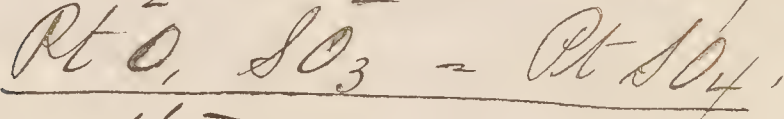
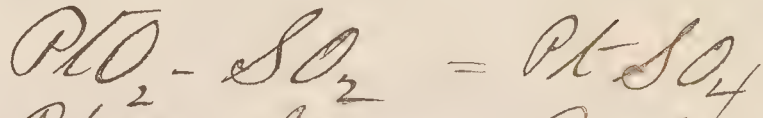
this difference depends upon the

different positions of the atoms

Bodies of this kind we call Iso-

meric bodies + they occur

frequently in both branches
of our Science - for instance



show the same atoms & the
same number of atoms &
yet the Chemical Character
of these compounds is different.

honor. phenomena This difference in these bodies
is a proof of the difference
of atomic positions in the com-
pound for no other possible
ground of difference is ca-
pable of being brought for-
ward to account for so sin-
gular a phenomenon.

Allo-
tropic The Elements - when they show
this difference - are called -
Allotropic - & the conditions
that are the abnormal ones -
the Allotropic Cond. (O. C. B. Src)

Wasserstoff. H.

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Exceedingly abundant in Occurrence,
nature, next Oxygen perhaps
the most abundant element
free, however, from combination
it seldom appears - only in
some volcanic eruptions &c
& in wholesale Organic decom-
positions has it been known
to occur in a free - or uncon-
bined state. It forms a con-
stituent of Water - covering
with Oxygen $\frac{2}{3}$ of the globe. HO
& forms by weight $\frac{1}{9}$ of the mass.

In most Organic tissues
it has a part - both in the
Animal & in the Vegetable
World. But in the decompo- Organic
sition of the same - it is at Complete
Once converted into Water - &
as above remarked only seldom
shows itself free in Nature.

Water is so universally
 Manufac. abundant in Nature that
sure if we can manufacture
 it from H_2O , it would by
 all means be the best.

There are many substances
 which have a greater affini-
 ity for Oxygen than H - &
 we have only to bring them
 into contact with H_2O , under
 favorable conditions, it will
 unite with O, & set H free.

An example of such a sub-
 stance is Sodium (Natrium)
Na which has so strong an af-
 finity for Oxygen, that it
 will decompose water without
 the aid of heat

result $\text{Na} + \text{H}_2\text{O} = \text{NaOH} + \text{H}_2$

If the gas be tested it will show
 the properties of H - (ment. hereafter)

This property has been made
 a peculiarity on account
 of which to divide up the ^{Division}
 Metals into groups - for the ^{of the}
 various Metals show with Metals
 water very different behaviors.
 Some of them possess the
 property of decomposing
 it at ordinary temperatures -
 Uniting with Oxygen & setting
 Hydrogen free - Others a-
 gain, do not act upon it
 at ordinary temperatures - but
 Only at a red heat - but
 when, at Ordinary tempera-
 ture, an acid is given to the
 water - they decompose the
 water vigorously, like the
 first mentioned Metals -
 Others, again will under no circum-
 stances separate H_2O into H & unite with O
 of the H_2O . (the)

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Decom-
position
of
Water

Those metals which do not decompose H_2O at ordinary temperatures are by far the greatest number. Some do not decompose H_2O , under any circumstances. Au. Pt. &c. others again; only in presence of an acid. — some again only in the white heat.

At Ordinary temperatures the following metals decompose Water — : —

Sodium group = Na.

Potassium do = K. Rb. Cs.

Magnesium do = Mg. Li.

Alkaline Earths — = Ca. Ba. Sr.
~~~~~

In the red heat — or in the presence of the following acid, the following metals decompose Water —

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Manganese Group = Mn. Fe  
Vr. Cr. Ni. Co. Zn. Il.

The following metals -  
do not decompose water at  
Ordinary temperatures - nor  
at any temperature - nor  
in the presence of an acid -  
(except Bi + Cu - which in Note  
the White Heat - decompose  
it difficultly) -

Cu. Bi. Pb.  
Au. Pt. Hg. Ag &c &c  
in fact - all the Noble Metals

This division is of some im-  
portance as a general one  
but - it possesses the Obje-  
tion that is too general &  
many special properties -  
of the metals - classed by  
their behavior to water, &c.

ers. are so different -  
that were we to apply  
this peculiarity - as a  
means of division many  
incompatibilities would  
ensue. So that - we gen-  
erally - use this property

Ditto as an accessory one, in  
the divisions of the Metals.  
It is more important prop-  
erties, + more distinguishing  
ones as a means of group-  
ing them - as will be seen  
hereafter.



# Lecture 30<sup>th</sup>

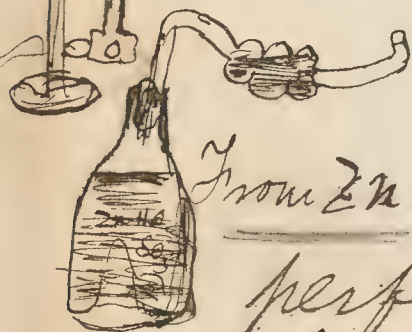
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## Wassersstoff

Manufacture H by the decom-  
position of Water - by Iron - at red  
heat.

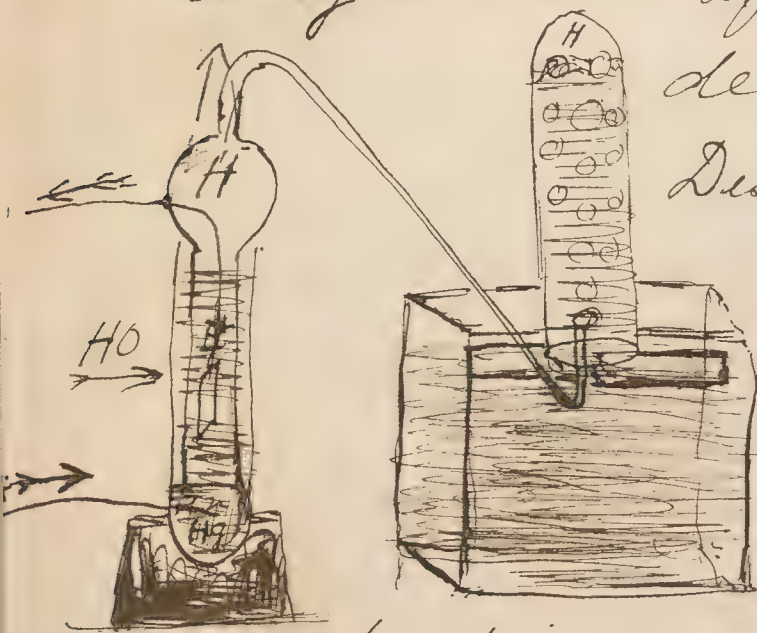
## Manufacture

Ditto from Zn. with  $H_2O +$   
 $H_2SO_4$ .



From Zn.

The best method of  
obtaining the gas  
perfectly pure is to obtain  
it by means of the electrical  
decomposition of  
Distilled Water.



by means of Exp  
an apparatus  
like the one  
represented in

the figure immediately  
above.

As thus obtained Hydrogen  
Properties is a colorless, odorless, taste-  
 less <sup>incondensable</sup> gas - in so far re-  
 sembling Oxygen, of very  
 slight specific weight -  
 Whence its use in lifting heavy  
 weights, & its adoption for  
 Ballooning & A very power-  
 ful reducing agent, as  
 energetic in its action as car-  
 bon.

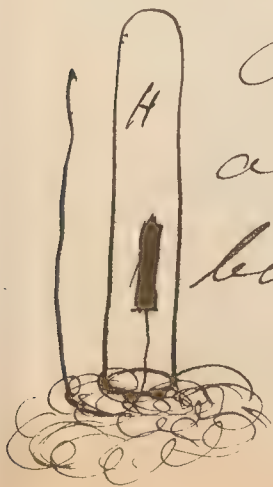
If it could be condensed to a  
 liquid or a <sup>(solid)</sup> gas it would possi-  
 bly resemble very closely Mer-  
 cury or Zinc, for in all its  
 compounds it shows the  
 greatest resemblance to the  
 Metals, & we have good  
 reason to suppose that it  
 is a metal in a gaseous - as Hg  
 is a ditto in a liquid state.

It is the lightest of known Specific bodies - Specif. Grav. being Gravity. 0.0692 (Air = 1) making it therefore  $14\frac{1}{2}$  lighter than air.

Hence its peculiar adaptation for Aërial voyages.

Absorption's Coefficient of Hydrogen for Water very small. +

This appears ~~appears~~ for considerable temperature changes - Absorption to be the same. Its action tion on test paper. is perfectly neutral. Is not altered by the presence of  $\text{CaO.H}_2\text{O}$ . Does not support Combustion, but is itself combustible (on the old theory).



A candle - thrust into a jar of H. is extinguished but - the Gas itself consumes itself in Comb. with O.

Exp



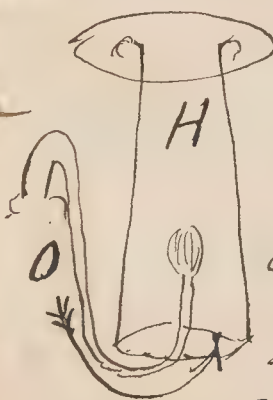
Spectrum

When heated to glowing - it gives out certain kinds of light which in the spectrum are characteristic for  $H$ . By its Combustion with  $O$ , an immense amount of Heat is generated;

Combines directly with  $O$  to form  $HO$ . When heated in contact with  $O$ , the  $H$  takes fire + is hence called a combustible.

Exp.  
Combustion of  $H$ .

of  $H$  in  $O$  or  
of  $O$  in  $H$



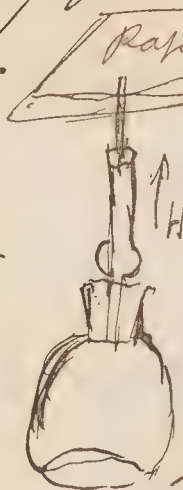
But if the operation be reversed - + a stream of small dimensions, be lead into a jar of  $H$ , the Oxygen - will take fire + what was before the combustible - is now the supporter of Combustion. This destruction of all gases

into Combustibles & Sup- Combustibles  
 porters of Combustion was form- Supporter<sup>+</sup> of  
 edly regarded as of great impor- Combustion  
 tance - but there is also Division after  
 lutely no reality in the division ~~Combustion~~  
 for when 2 gases combine it is dif-  
 ficult to say which gas <sup>burns</sup> ~~partakes~~ or  
 whether both do not partake of the  
 phenomenon of light; & what is -  
 more the operation may be appa-  
 rently reversed - as was Contact  
 seen in the last Experiment. Action of  
 By bringing a piece of Pt.  
 Platinized Sponge freshly Ex.  
 flowed - over a stream of  
 Hydrogen - the phenomenon  
 of Contact action may be  
 fully illustrated. Here the  
 Heat derived from the combina-  
 tion of  $H + O$ , upon the immediate  
 surface of the Pt. is sufficient to



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Exp 195 inflame the Gases. With Pt or  
 Great Dy. cable it is otherwise.  
 fusibility of H<sub>2</sub> & O<sub>2</sub> To illustrate the def.  
 fusibility & extreme ten-  
 sity of H, a piece of glazed  
 writing paper - may be  
 held above it at some distance above



a stream of the gas, & yet it may  
 be inflamed through the paper.  
 If the gases H + O are pre-  
 viously mixed in the propor-  
 tions by volume <sup>by which</sup> they combine  
 by nearing it to a burning  
 taper the mixed gases com-  
 bine with an explosion.  
 Caution must be used therefore  
 in handling jars of this gas,  
 which have been set into

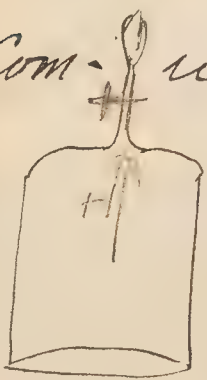
Explains the atmospheric presence -  
how for by the diffusion's laws  
 as we know, no gases can



be kept for any time, in Explanation  
 each others presence, though  
 kept above a fluid ( $Hg$  or  $H_2O$ )  
 without diffusing into one another,  
 & cautious handling may pre-  
 vent rise to accidents.

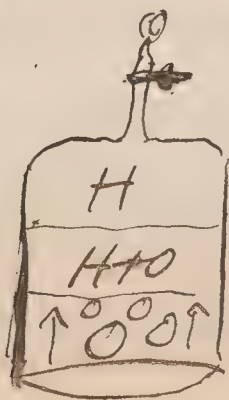
With a thin glass vessel the ex-  
 plosion is much more violent  
 because, here the gases, can Exp  
 under the influence of the use a bladder  
 immense heat generated & soap bub.  
 by combining, expand freely blow  
 for the walls of the contain-  
 ing vessel offer but little  
 resistance, & break easily.

Coming into contact with Exp  
 the cool atmosphere -  
 the  $H_2O$  instantly con-  
 denses; & the air can  
 freely rush into its place -  
 giving rise to the great noise.



This freedom with which the air can rush in to fill up the vacuous space, gives us a far louder sound - than when the vessel remains unbroken - & the air is necessitated to enter - comparatively slowly at the opening of the bottle.

If H is burned by simply allowing it to stream from a point - & the containing vessel be open beneath (see 196) - presently there will be an explosion - on account of the Oxygen which has diffused so soon into the outstreaming gas.



## Lecture 31<sup>st</sup>

If we mix the gases  $O + H -$  with a third gas. which does not combine the temperature of combination will be much lower. (as was seen in the introduction) & the more of this indifferent gas is present the lower will be the temperature of combust - & we will finally reach a point where no combination will take place.

Hydrogen compounds with Oxygen.

There are 2 of them -

$H_2O$  = protoxide of  $H$ .

$H_2O_2$  = superoxide " "

Compds

Ordinary water. An analysis  $H_2O$  or a synthesis of  $H_2O$ , may be made, to determine its quantitative composition.



Synthesis, Place in the Eudiometer  
 by the first a volume of Oxygen -  
Eudiometer (+ by bringing about the  
 same conditions of temperature  
 & pressure - namely by placing  
 ditto under  $H_2O$ , we can avoid  
Exp reducing the gas volume),  
 then bring into it a very cer-  
 tain quantity of  $H_2$  & explode  
 after reading off the vol-  
 umes

$$O = 15^{cc} \quad \begin{array}{r} 3-5-cc \\ 15- \\ \hline \end{array}$$

$$O + H = 55^{cc} \quad 40^{cc} = \text{Vol. } H_2$$

Explode the gases & read off  
 after cooling again in Water  
 after Explosion  $V = 10^{cc}$   
 (test the residue to show that  
 it is  $H_2$ )

$40^{cc}$  of  $H_2$  were put into the Eud.  
 $10^{cc}$  " " remained over.  
 $30$  " " " combined with  $O_2$

That is  $30^{\text{cc}}$  of Hydrogen. Comb-  
ined with  $15^{\text{cc}}$  of Oxygen. Or -  
they combine in the simplest  
relation by volume -

This simple relation is not  
only the case with gases  $\text{H} + \text{O}$ ,  
but is a universal rule in  
the union of gases.

If we know the relation of  
 $\text{H} + \text{O}$  in water by volume we  
know also the relation of those  
elements by weight - from a  
simple proportion of the Sp. Grav.  
of these gases.

$$\begin{array}{rcl} 773 \text{ c.c. O} & = & 1.106 \\ 2 \times 773 \text{ c.c. H} & = & (0.0692)2 = 0.1384 \end{array} \quad \begin{array}{l} \text{Determinations} \\ \text{of} \\ \text{Weights} \end{array}$$

$$\begin{array}{rcl} 2 \times 773 \text{ cc HO} & = & 1. + = 1.2444 \text{ or} \\ & = & 773 \text{ cc HO vapor} = 0.6222 + \end{array}$$

which in reality is the specific  
gravity of aqueous vapor -  
compared to Air = 1

Relation bet.  
several Gases  
comp. Weights  
 & Volumes.

We have seen that specific gravity is the weight of a substance (here a gas) with certain conditions of temp. & pressure observed - compared with the weight of <sup>an</sup> ~~some~~ equal volume of some other substance (here air) which last weight is taken as a unit. But we have seen too, that gases combine in certain definite & simple proportions by volume

Volume  
 of this  
 Resulting  
Compound

as well as by weight; hence we draw the sequence that an intimate relation exists between the specific gravity & atomic weights of gases.

The volumes of the compounds resulting from the union of two or more gases too always a simple multiple of that of the constituents before union.



And this sequence is found to be absolutely true in nature. Grav. represents For; if we will notice the relations which the ~~atomic~~ Atomic Weights Specific gravities bear to each <sup>or a multiple</sup> of it. Other we will find that relation is expressed by the atomic weights. in other words - that the ~~atomic~~ <sup>specific</sup> gravities of all gaseous elements are to each other (~~by weight~~) as the Atomic Weights, or this relation is in a simple multiple proportion.

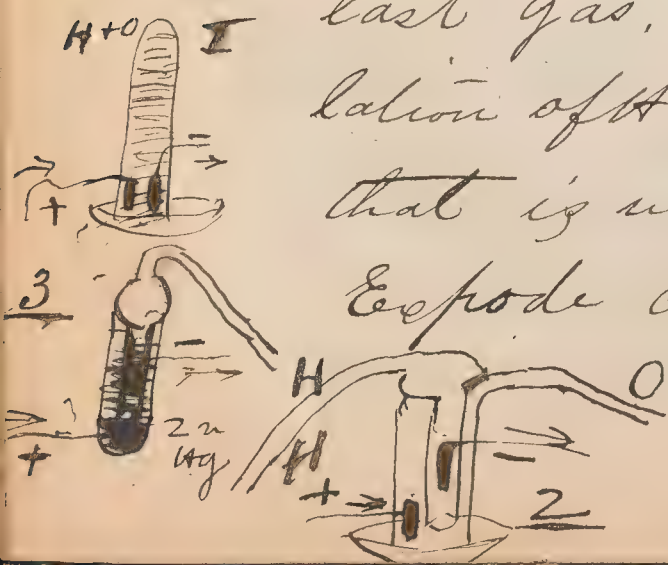
This if we call the sp. gr. of H=1. (that is = Atomic Weight) & reduce the Sp. Gr's of all the other gases to that standard

We have →

| Sp. gr.      | sp. gr. of | Equivalents        |
|--------------|------------|--------------------|
| <u>air=1</u> | <u>H=1</u> | <u>of the same</u> |
| H=0.0693     | 1          | 1                  |
| O=1.108      | 16         | 8                  |
| N=0.969      | 14         | 14                 |
| Cl=2.458     | 35.5       | 35.5               |

Analysis A synthesis of  $H_2O$ , showed  
 of  $H_2O$  not satisfy us - but we will  
 decompose  $H_2O$  into its ele-  
 ments - by the Galvanic Battery.  
 Here again we will find  
 that just as we could set  
 $H_2O$  together from 1 vol.  $O + 2$  vol.  
 $H$ . Water will be decomposed  
 into  $H + O$  in the proportionally  
 vol. of  $O = 1$  vol  
 $H = 2$  vol.

Perform the experiment of de-  
 composition in three vessels,  
 in the first catch the mixed gas-  
 es, in the second -  $H + O$  separately  
 & in the third -  $H$  alone, burn the  
 last gas, show that the volume re-  
 lation of  $H + O$  in the 2<sup>nd</sup> is correct,  
 that is in prop. of 1 to 2 - &  
 Expode the ~~third~~ first gas.



## Lecture 32<sup>nd</sup>

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The amount of electricity necessary for any purpose - (to decompose a chemical compound - for instance) & the intensity of the same - can be measured by the tangent needle.

The amount of Electricity that flows in one unit of time through the circle is proportional to the tangent of deviation of the needle.

He finds that the same amount of Electricity is the same for equal lengths of a chain.

1<sup>st</sup> Law.

The amount of ~~Electricity~~ decomposition brought about in a chemical compound - is directly proportional to the amount of electricity brought into contact with the compound.

2<sup>nd</sup> Law



2<sup>nd</sup>  
Law.

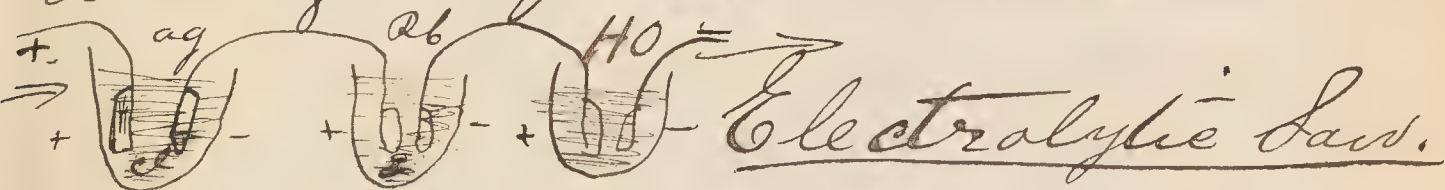
The amount of decomposition  
by the same amt of electricity is  
always proportional to the time  
Decomposition  $\propto$  It.

If we have once determined  
how much electricity is neces-  
sary to decompose - for instance -  
one C.C. of a chemical comp'd, we  
have a measure for the amount  
of any electrical stream - as  
sharp & much easier to deter-  
mine than by the tangent needle  
for, we need only in each case  
measure the amount of  
decomposition which has taken  
place - in order to determine  
accurately the quantity of  
Electricity necessary to effect  
that decomposition, in terms  
of Intensity & time - the latter  
being given - the former determined

## Parraday's Law.

If we lead a stream through various chemical substances.

(Ag Cl. Pb I &c) - ~~as~~ the quantity of each element decomposed, is directly proportional to the atomic weights of <sup>each</sup> ~~these~~ elements.



108 ag. 35.5. Cl. 127 I. &c &c

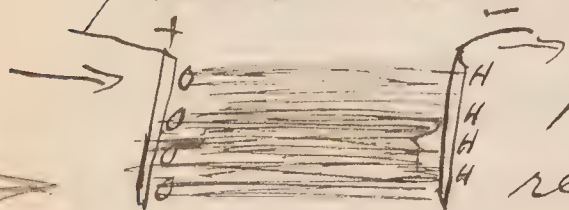
If we proceed out from the Atom. only or from Sp. Heat, ~~do not~~ ~~corresponds~~ the atomic weights obtained do not correspond with each other - If we proceed from the amount of electricity ne-

cessary to effect the decomposition of a unit of weight of any comp'd, we obtain numbers which agree almost in each case with those which we call Equivalents.

# Electrolysis

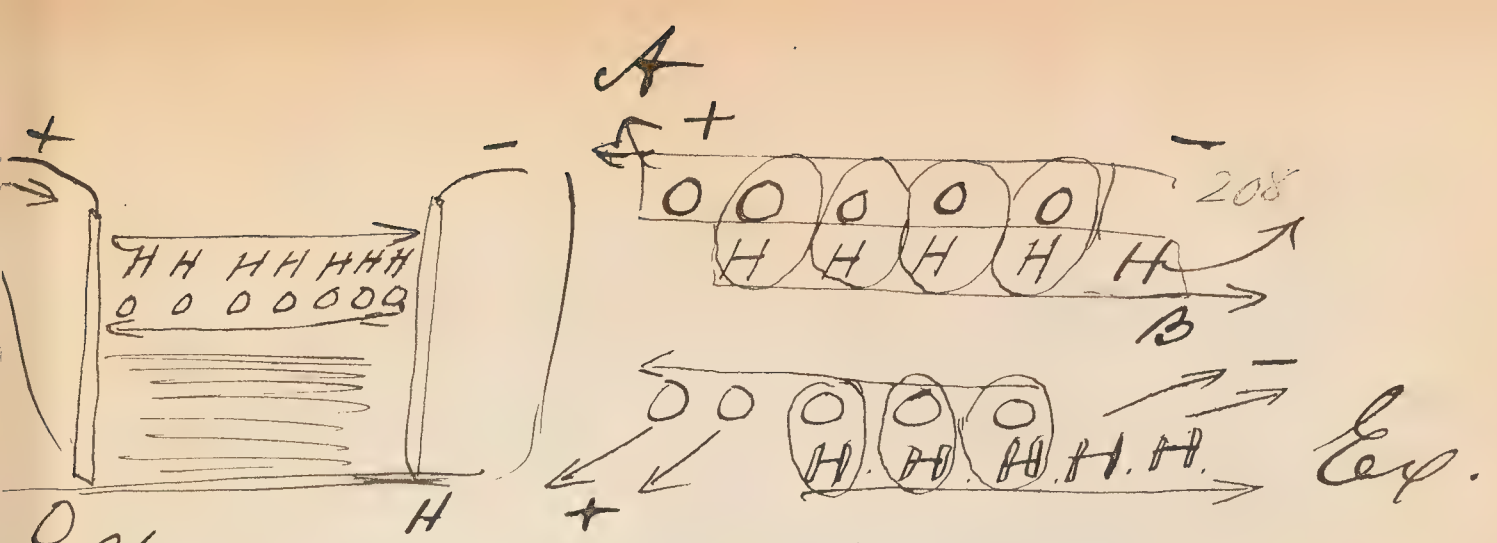
Let us examine now the phenomenon of decomposition of bodies itself. Do all bodies suffer decomposition by Electricity? Answer. Yes - if the stream passes through them, & it appears that it is the lower compounds particularly which are the best conductors.

We saw also that; The various elements were set free at opposite places - but not at intermediate

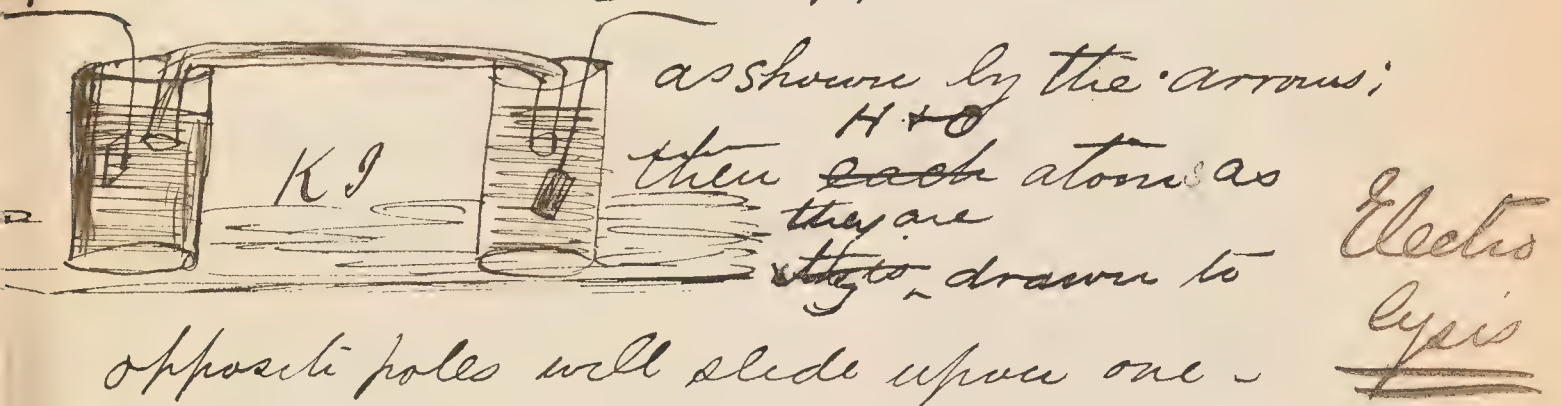


places in the current. We might suppose that, if a particle of water (for ex) was decomposed at the positive pole (that is, separated into its constituents), not only the Oxygen but also the Hydrogen should be given off there - But it is not. Why? A very simple positioning of the atoms of  $H_2O$  will explain.





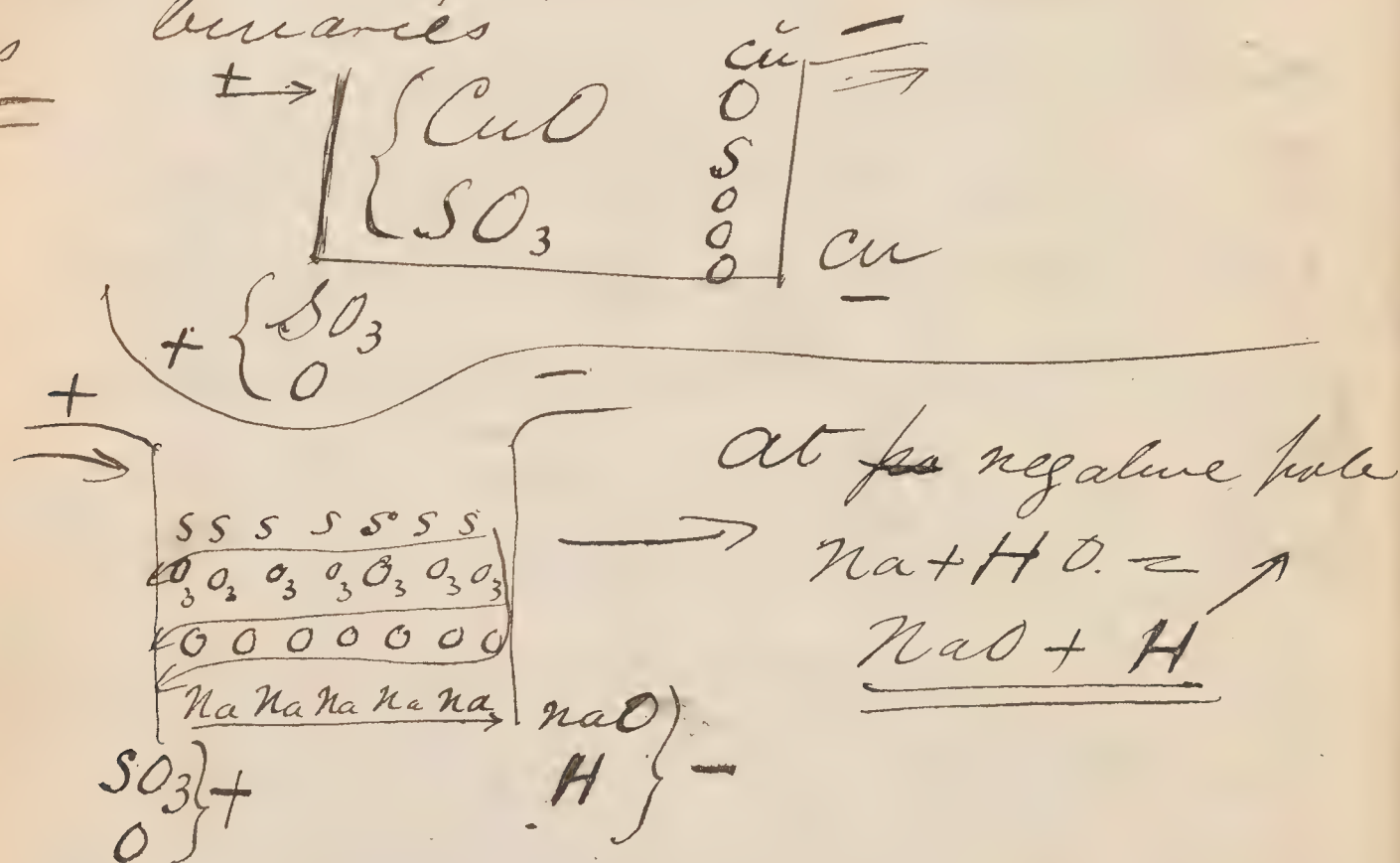
We need only imagine the atoms of  $H+O$  positioned side by side - & each atom attracted in opposite directions



opposite poles will slide upon one - another - an atom of  $O$  will be given off at A, at the same time that an atom of  $H$  is given off at B, & the next atom of  $H$  will be carried over to & unite with the next  $O$  atom moving in the opposite direction. So the next atoms of  $H+O$  - will be given off at B & A respec. & the next atoms of  $H+O$  unite; & so on, till the stream ceases. (With KI solution in two beakers, connected with a tube - only the Starch solution in contact with the pole (+) will be blue -

Electro-  
Types

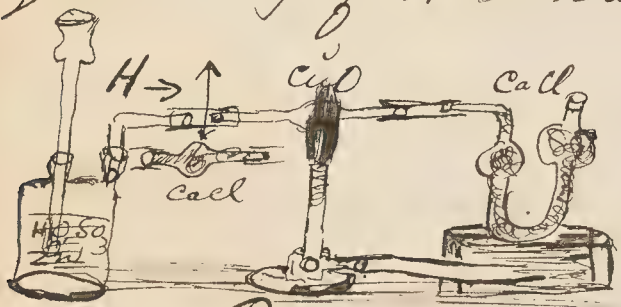
We know also that ternaries  
are decomposed as well as  
binaries



With  $\text{CuSO}_3 - \text{SO}_3 + \text{O}$  go off at the positive pole. While - metallic Copper is separated upon the negative (electroplating). With  $\text{NaO}$ ,  $\text{SO}_3 \rightarrow \text{SO}_3 + \text{O}$  go off at <sup>positive</sup> ~~negative~~ pole -  $\text{Na}$  at ~~negative~~ pole. but here  $\text{Na}$  decomposes  $\text{H}_2\text{O}$  of solution forming  $\text{NaOH} + \text{H}$  is given off.

## Lecture 33<sup>rd</sup>

Lead Hydrogen gas, Wasser =  $H_2O$   
 over a glowing met. Analysis  
 allio oxide, (a weighed quan-  
 tity), the loss of the Oxide gives us  
 the quantity of Oxygen combined with  
 H. the  $H_2O$  gives us both H + O. if  
 first be taken from last - gives us  
 quantity of H combined.



$H_2O$  - by reduc-  
 tion of  $CuO$ . Exp

Results of Analysis.

Röhrchen mit  $CuO$  =

Vor dem Versuch =  $20^{\text{gr}} 45$

Nach " " =  $18 \quad 55$

Oxygen lost =  $1,90$

Lead Rohr.

Vor dem Versuch =  $10^{\text{gr}} 272$

Nach " " =  $12,490$

Water formed =  $2,137$



|                                         |               |              |
|-----------------------------------------|---------------|--------------|
| $\text{H}_2\text{O gained} = 2.137$     | } Subtracting |              |
| $\text{Oxygen lost} = \underline{1.90}$ |               |              |
| $\text{Hydrogen} = \underline{0.237}$   |               |              |
|                                         |               | gives us the |
|                                         |               | amt of H.    |

That is, with 1.90 grms Oxygen, combines

0.237 grms of Hydrogen :- or -

0.237 : 1.90 :: 1 : 8 - or exactly the

proportions of their Equivalents.

This method can be used to analyze not only Oxygen but also metallic oxides - In this way too the most of the analyses of metallic Oxides have been carried out.

$\text{H}_2\text{O}$  - tasteless, ~~colorless~~, not changed in ordinary temperature & light

Properties - Color is blue or aqua marine. If we look through a small depth of Water - it appears colorless - but if we allow the light to pass through a deep column of it we obtain the real color - aqua marine.

Most bodies show their colors  
 more clearly when heated, so  
 also with Water, in tropical seas  
 the color of the sea is seen far  
 more clearly than in northern ones.  
 The higher the temperature the more  
 light they emit. The color of colors of  
 rivers - lakes &c &c, is always Rivers &  
 more or less tinted with foreign Seas.  
 bodies - solid - &c which they hold  
 in suspension, & it is only where  
 the Water is perfectly clear &  
 free from these impurities that  
 the color appears in perfection.  
 Ice shows the same blue color of  
 liquid  $H_2O$ , only more intense, &  
 so, too, watery vapor, for it is owing  
 to this <sup>fact</sup> ~~color~~, that the blue  
 color of the heavens is due - &  
 the clearer the heavens are from clouds  
 the more beautiful & deep is the color.

It is decomposable at  $200^{\circ}$  or so - at into  $H + O$ . but only partially, at a much higher it is totally decomposable.

With a ~~cold~~ hot piece of Platinum a small quantity of  $H + O$  - is formed, in cooling it passes again through the temperature of combination & forms  $HO$ , hence

only the smallest quantities can be obtained.

exceptional There is one characteristic property that  $HO$  possesses, upon which of  $HO$ , too great importance cannot be placed. It is possessed by only two or three bodies besides; namely: -  
 Its behavior in Expansion & Contraction. Most bodies (liquid) expand regularly by heating - & contract more & more in cooling - till they pass into the solid state - when they



Contract still more - (that is become Ditto  
 Specifically heavier) & when solid becomes  
 most dense, or generally - the lower the  
 temper. the greater the density; - not so  
 with H<sub>2</sub>O; it expands truly when heated -  
 & when cooled contracts - but only for  
 a certain number of degrees; - it contracts  
 by lowering <sup>the</sup> temp. till it has reached 4°C  
 here it is most dense, cooled beyond that -  
 & <sup>in</sup> ~~after~~ freezing it expands. ←

In Nature this peculiarity plays  
 a great part. For the same  
 quantity of ice by volume is  
 lighter than ditto of Water - that is  
 sp. grav. of ice is less than H<sub>2</sub>O,  
 & swims upon it - To this we  
 owe everything connected with or-  
 ganic life upon land & sea. For  
 if Water obeyed the ordinary law  
 that governs liquids generally  
 & contracted regularly by cooling

Facts

Ice, when formed would sink to the bottom of rivers & lakes &c., & fresh masses would be formed which would follow suit. In even temperate zones the rivers would then in ordinary winters be frozen to the bottom. The greatest warmth of summer, would then be insufficient to melt this vast accumulation of ice - for Water is a very poor conductor of Heat. The next winter would repeat the process - & extend the Ice formation into the tropics every <sup>year</sup> ~~year~~ <sup>bringing a</sup> ~~year~~ would fair in the ant &

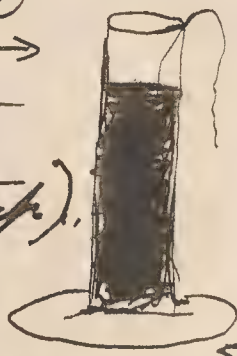
Temp-  
erature  
here  
would be  
that of  
the  
Arctic  
Regions in  
the neigh-  
borhood of  
the Poles

limit of Ice & finally the world must be covered - wherever H<sub>2</sub>O ex-  
isted with a sheet of ice extending to the bottom of the Seas. The effect upon climate would be then such as to preclude the possibility of the existence of Animal life

Upon it depends the fertility of the soil; & more so the presence of Organic life in the seas. For H<sub>2</sub>O ~~self~~ contracts till it reaches 4°C, then is at its Maximum density, & sinks - the whole mass of H<sub>2</sub>O must ~~be~~ <sup>have</sup> reached 4°C, from top to bottom before freezing can set in. When a mass of H<sub>2</sub>O on the surface is colder than 4° it swims, & when a sheet of ice is formed it falls out.

Hence the accumulation of ice, (this being a bad conductor of heat) is slow, & never exceeds a few inches.

Water in Expanding exerts an immense pressure.

It can easily be shown by filling a bulb - HO at 50°  completely with H<sub>2</sub>O (ord. temp.).

& placing the same in a cylinder containing water about at 50° in a few minutes the strongest bulb of glass will be broken.

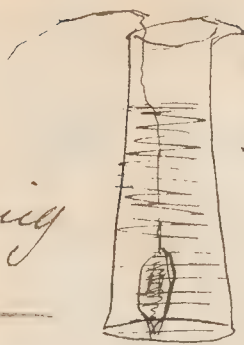
Expansion of Water

by Heating

Expans.



Exp  
 Ditto  
 By Freezing  
~~Exp~~



Show that water expands  
 equally upon cooling  
 (freezing) - place another  
 similar bulb - of  $H_2O$  in  
 a freezing mixture, of  $Na_2SO_3 +$   
 $2H_2O + HCl$  (conc). As before the  
~~bulb~~ bulb will be bursted.

Disint.  
 gration of  
Rocks The action of  $H_2O$ , in Geology,  
 & its influence in giving the  
 form of the Earth's surface is  
 & always has been immense,  
 Rocks are constantly disinte-  
 grated (water pouring over them with  
 sharp sand - or freezing in their interstices)  
 their debris is carried away in  
 suspension to the rivers - & there  
 spread out in their deltas or lakes  
 or carried to the sea & spread  
 out by its currents - (for its power  
 see Lyell, principles of Geol-  
 ogy).

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The Specific of Warmth of  $H_2O$  is immense - that is - a great Sp amount of Heat is necessary to Heat raise its temperature in comparison with other bodies. Its effect upon climate is easily pointed out, the surface waters of the tropics - Effect highly heated, are kept in cons - upon tant circulation, for as these Climate waters become heated + rise - cooler waters from the north rush in along the bottom, + reaching the Equatorial regions become in their turn heated + rise - the same process is continued, keeping up a constant circulation; the warm surface water flowing North, the deep cool water flowing to the south (in the Southern Hemisphere this direction would be reversed). The specific Heat

Ditto

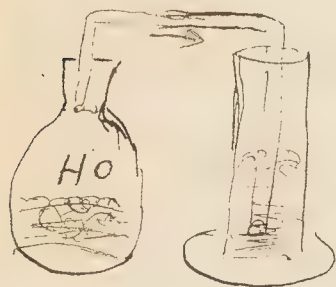
of  $H_2O$ , is about 4 times that of Air, that is, it takes 4 times as much heat to heat a certain weight of water ~~thru~~ through a certain number of degrees, than, to bring the same weight of Air to ditto. Hence coming in contact with Cold Air - the water, ~~the wat~~ will naturally be cooled  $\rightarrow$  but in losing  $1^\circ$  degree of Heat - the Water will heat ~~through~~ ~~thru~~ the same weight of Air - through  $4^\circ$  - Hence the great difference in Climate of coast countries & of Continental ones, in northern zones, (England Ireland), The former being always much milder in temperature than the latter.



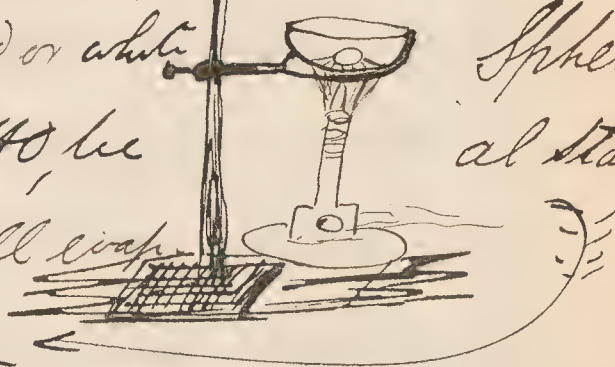
## Lecture 34<sup>th</sup>

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In passing from a liquid to a gas,  $H_2O$  takes up, a large amount of heat to become a gas. It can use this property to heat bodies that can not be directly heated. Latent Heat of  $H_2O$ .



heated - (1 lb of  $H_2O$  vapor heats to boiling 5.36 lbs of water. If a platinum cup be heated to a red or white heat - & a globule of  $H_2O$  be thrown upon it, it will evaporate slowly. Spheroid. al state. Explain.



### Chemical Properties

$H_2O$  can combine with simple & compounds. (el. Br. for example) With compound bodies - it plays the part of an acid & at times of a base.

$K_2O$ , the strongest base, combines with great heat with  $H_2O$ , by decomposition separates again into its constituents  $K_2O + H_2O$  -

HO  
 plays the  
 part of  
an acid

What ground have we to  
 call the water acid? - for HO is  
 neither acid nor base - it does  
 not neutralize the alkaline prop-  
 erty of KO, in the slightest - But -  
 If we bring an acid -  $SO_3$  - into  
 contact - with it - the water is dis-  
 placed & the acid combines in its  
 (HO) place with the Anhydrous  
 KO - the water then has supplied  
 the same place as the acid -  
 hence we call it Acid Water

of a  
Base

Again - We take a strong  
 acid  $SO_3$  - it & bring into con-  
 tact with it a combination takes  
 place with great heat & explosion  
 an acid will not displace it  
 But if a base (KO) is brought  
 into contact with the compound - it  
 displaces the HO, & supplies its  
 place in combination -

Again, water can unite with compounds & play neither the Crystal part of an acid nor of a base. Water If an Anhydrous salt  $\text{Na}_2\text{SO}_3$  be dissolved in  $\text{H}_2\text{O}$ , & allow it to crystallize it will take up Water into it & form a union - ( $\text{Na}_2\text{SO}_3 + 10\text{H}_2\text{O}$ ) (Here it is neither an Acid nor a base), it can not be displaced by an acid nor by a base - but - by simple heating - or sometimes by simple evaporation in the air the salts loose their Water of Crystallization as it is called. Those salts that loose their  $\text{H}_2\text{O}$  of Cryst. by simple evaporation we call Efflorescing Those that take up  $\text{H}_2\text{O}$  with avidity & become liquid if laid in the air we call deliquescent; Those that snap in a fire owing to  $\text{H}_2\text{O}$  in their pores - Decrepitating



$HO_2$  (D, HO)

If we decompose  $H_2O$  by electrical decompos. there is always 2 or 3 per cent of this peculiar compound formed - but this quantity is so small, that it (the method) is seldom used for its manufacture.

If we bring  $BaO_2$ , into contact with a dilute solution of  $H_2O + SO_3$  in excess of water, it is formed

$$\left. \begin{array}{l} BaO_2 \\ H_2O + SO_3 \end{array} \right\} \begin{array}{l} BaOSO_3 \\ HO_2 \end{array} \rightarrow$$

It is colorless + odorless like water. Specif-grav. 1.45 ( $H_2O = 1$ )

It is not neutral like water -

Brought into contact with many substances it oxidizes them - red & labile colors are, as with Chlorine

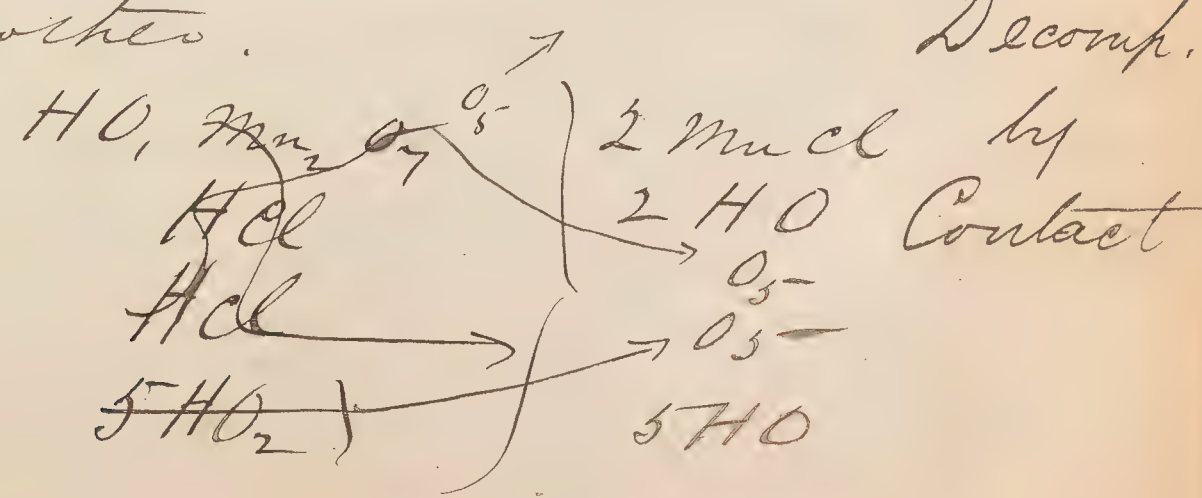
Bleaches Bleached - by this Oxidation

It is also very unstable

Bases (Strong parties) decompose it into  $H_2O + O \rightarrow$  Acids will not. but acid Analysis in preserving this unstable comp'd. of  $H_2O_2$  - It is analyzed by weighing a quantity & by heating driving off the  $O$ . which is caught & measured.

The phenomenon of Contact was at first noticed through this body - by simple contact of many bodies (C or Pt. or  $MnO_2$ ), it is instantly converted into  $H_2O + O \rightarrow$  Ex

Bodies that decompose  $H_2O_2$  can likewise be decomposed - & these two bodies are mutually decomposed by contact with one another.



Ex Perform the experiment.

We must have a reaction for  $H_2O_2$  - & we have one characteristic one for it.

If we bring  $H_2O_2$  into contact

Test  $\rightarrow$  with Bromic acid ( $BrO_3$ ) - solution a blue color is brought about

Sulphuric Ether - draws it out & dissolves it. What it is, is not known, perhaps a higher oxide of Bromine, above Bromic acid. The test is delicate.

$H_2O_2$  acts as an oxidizing agent.  $Pb, S \} PbSO_3$ .



Repair We use this property to bring back, restoring - the colors of Old Paintings,  $PbCl_2$  Paintings is used on Paintings, to keep the tints. But in course of time it is converted into  $PbS$ , by the  $H_2S$  in the Atmosphere.



phere - making the surface Black.

$H_2O_2$  smeared in diluted solution upon the surface of the picture oxidizes this to  $PbO SO_3$ , a colorless substance Exp thus - restoring colors - must be used Cautiously.

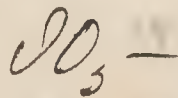
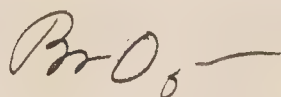
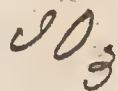
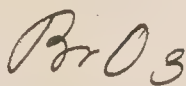
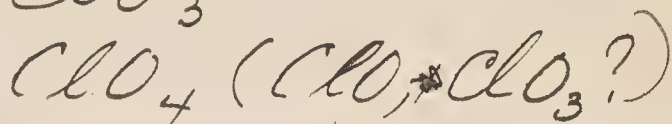
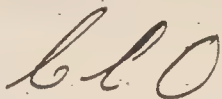
Cl. Br. I. Fl.

These bodies stand in such close relation with each other, that, all their compounds are extremely analogous.

They resemble Oxygen in the fact of being able to support Combustion like it - & according to the energy with ~~which~~ this combustion takes place, the Elements are arranged in order - 1<sup>st</sup> Cl, then Br, then Iodine, & lastly Fl.

With H, these bodies form only one compound -  $HCl$   $HBr$   $H I$   $H Fl$  all analogous compounds

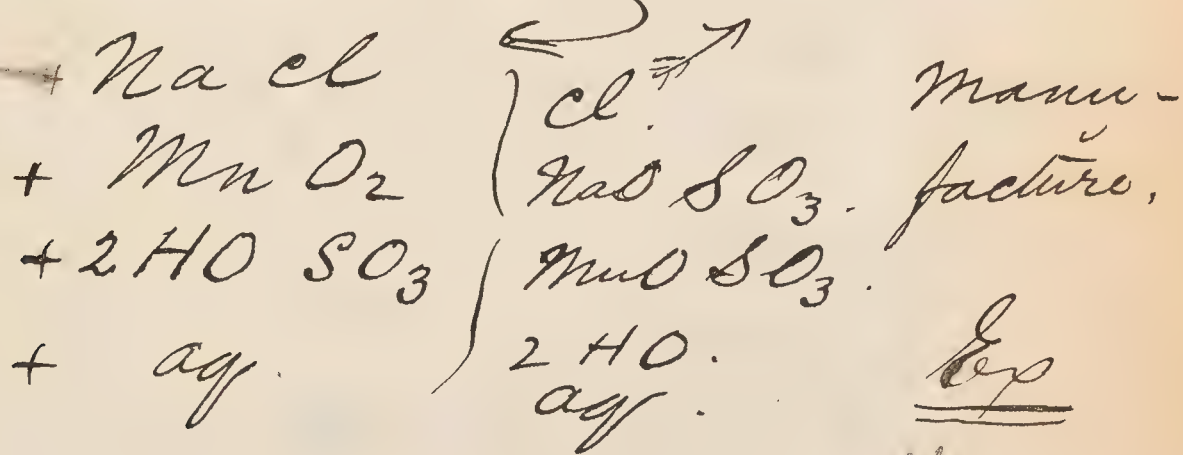
With Oxygen they form like-  
 Ox. wise very similar compounds -  
 Compds of acid Properties, & in the  
 same proportion. thus



Lecture 35<sup>th</sup>

## Chlorine.

Never comes free in Nature -  
 always combined - NaCl is  
 the most compound - Inorganic  
 & Organic World. KCl. CaCl  
 MgCl are very common in  
 sea water - HCl. in Volcanic  
 Eruptions - is very frequent.  
 To obtain Cl.  $\Rightarrow$

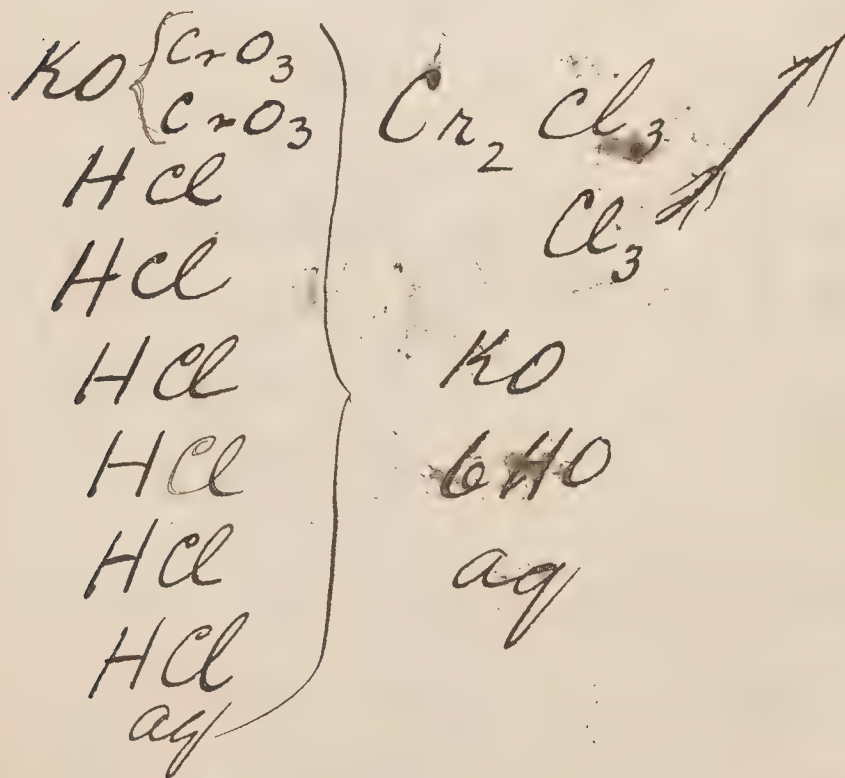
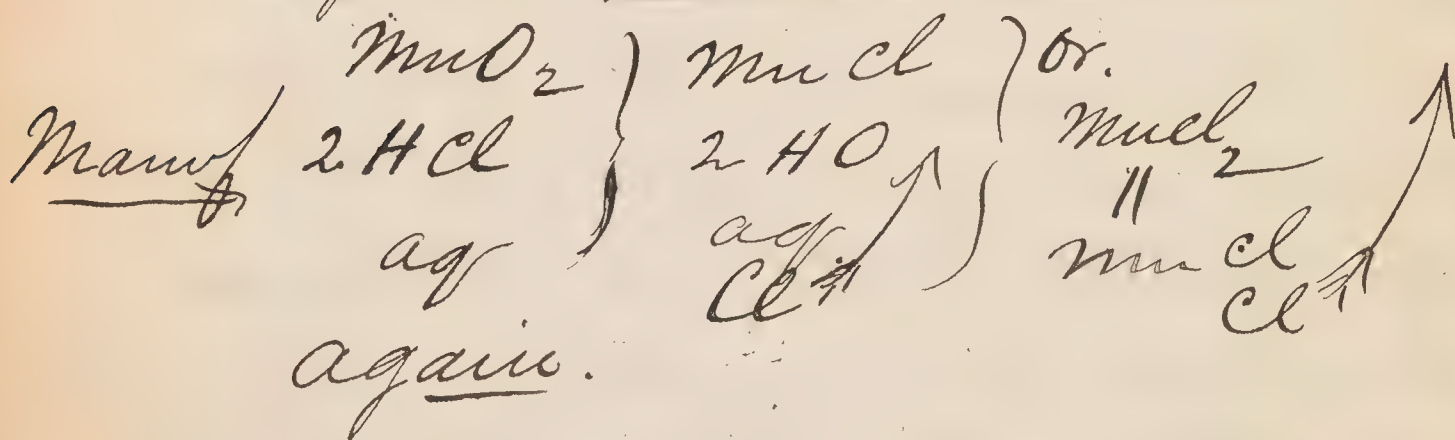


The excess of gas can be caught. To prevent  
 in a vessel of (C + CaO) both of Unpleas-  
 which have the property - ant results  
 of seizing upon Cl  $\Rightarrow$  in audit.  
 with acidity; thus saving  $\leftarrow$   
 the unpleasantness in a Lecture Room.





Caught over HO; HO must not be too cold, not under  $+9^{\circ}$ . HO otherwise combines with it. Hg cannot be used to heat it. for Hg combines instantly with Cl.



All the metals of the gold group namely - (Au, Pt, Pd, Rh, Ir, Ru, Os) if we glow them Chlorine compounds

give off the combined Cl<sup>230</sup>  
& leave behind metallic residues.

### Properties.

It is a yellow greenish gas,  
possesses a fearfully irritating  
& smell. is highly poisonous  
& if inspired concentrated in  
the lungs - is deadly - diluted  
with the air - it can be breathed  
without much danger. Attacks  
all animal tissues: (hence, too -  
the lungs - when breathed - the skin)

Sp. gravity 2.45307. (air = 1)

Atomic Wght. 35.5. (H = 1)

Liquid Cl. has Specif grav = 1.36 (H<sub>2</sub>O = 1)

It can be condensed by great  
pressure to a liquid. With H<sub>2</sub>O  
forms a compound under 9°C. 1 note  
above 9°C decomposes to Cl + H<sub>2</sub>O -  
or HCl + O. (Compound should be  
Cl + 10 H<sub>2</sub>O?) Has not been accurately examined.

Cl does not combine directly with O. Does indirectly.

With H it combines eagerly - if mixed in equal proportions it forms an explosive <sup>mixture</sup> compound, influenced by heat & light.  $\rightarrow$

Exp



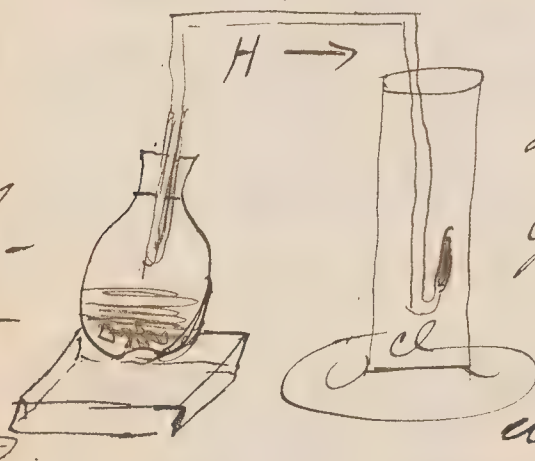
The resulting compound is not neutral like H<sub>2</sub>O - but an acid

Exp

I tested with Tincture Litmus - it reddens. (Test bottle of HCl gas)

Exp

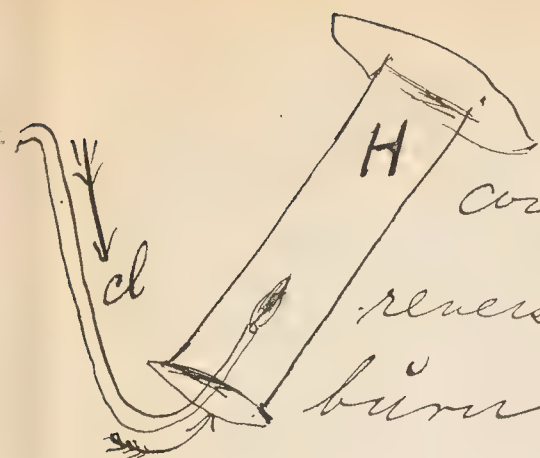
Comb-  
Cl +  
H  $\rightarrow$



With Chlorine gas Hydrogen combines giving a combustion phenomenon, (as in the case of H + O)

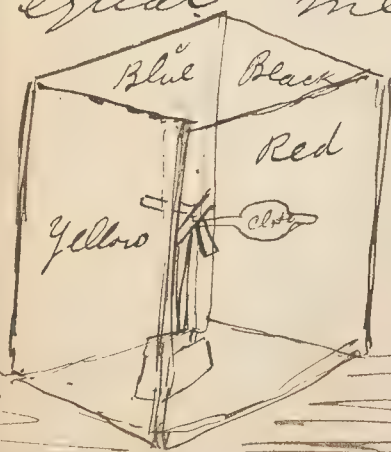
but the flame is <sup>of</sup> a pale blue color. Here we can burn H gas in a vessel of Chlorine - The resulting compound - is likewise an acid - identical with the substance tested above.





But just as we Burn  
 could burn H in O, or Cl in H  
 reversely O in H, so we can  
 burn Cl in H gas, showing  
 us again that the distinction Exp  
 combustibles + supporters of com-  
 bustion is purely an artificial  
 + unnatural one, + totally un-  
 supported by fact.

It is not always necessary to  
 heat H + Cl to combine them  
 but we can bring about  
 this combination by Light.  
 If we bring a bulb (of glass) with  
 equal measures of these gases  
 into the sun light, it  
 will explode with a Exp  
 allence. (Perform the  
 experiment.) Before  
 a glass box of various colored  
 windows the phenomenon is at-



Eis

tended with some peculiarities,  
 as it illustrates the fact that  
 there is an intimate relation be-  
 tween the kind of light vibra-  
 tions in affecting chemical union.  
 The kind of light which <sup>we produce</sup> ~~affects~~ <sup>& to affect</sup> this chemical union of  
 $H + Cl$  (& generally of all sen-  
 sitive bodies) has a decided  
 influence on the combination.  
 If we (see Experiment which showed  
 comes here) allow nothing but  
 red light <sup>(or yellow)</sup> ~~or yellow light~~ through  
 a glass window of either of these  
 colors to fall upon the Bulb —  
 no union will take place:— but  
 with blue, indigo &c an in-  
 stantaneous effect is brought  
 about, the  $H + Cl$  unite with  
 an explosion as in the Sun  
 light.

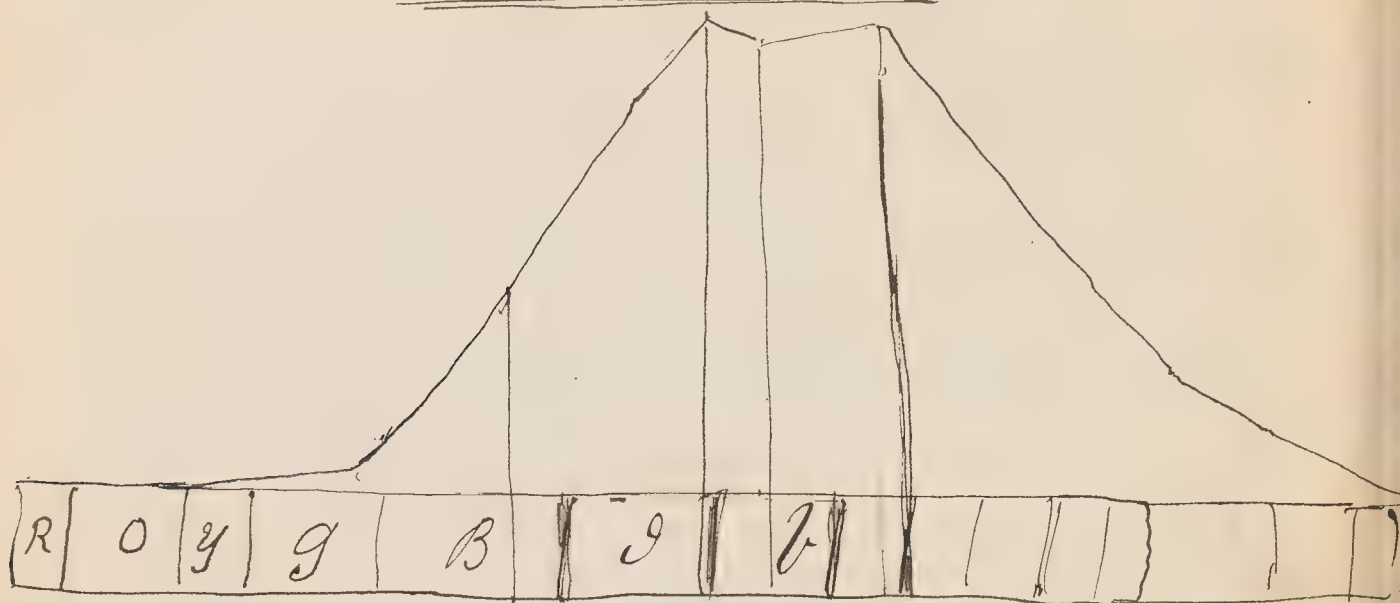
The yellow or red light which has no effect in bringing about a chemical action are just the colors <sup>for</sup> which the eye is most adapted, for all the colors mentioned - allow of distinct vision through them, The Yellow giving us the most distinct images - the red, scarcely behind - The blue glass - however - is far less adapted for distinct vision - than either the Red or Yellow - & allows us only a moderate vision -

The laws which regulate the effect of light upon chemical compounds - & combinations - are called the Photochemical Laws & will form the subject matter of the next lecture.



# Lecture 36<sup>th</sup>

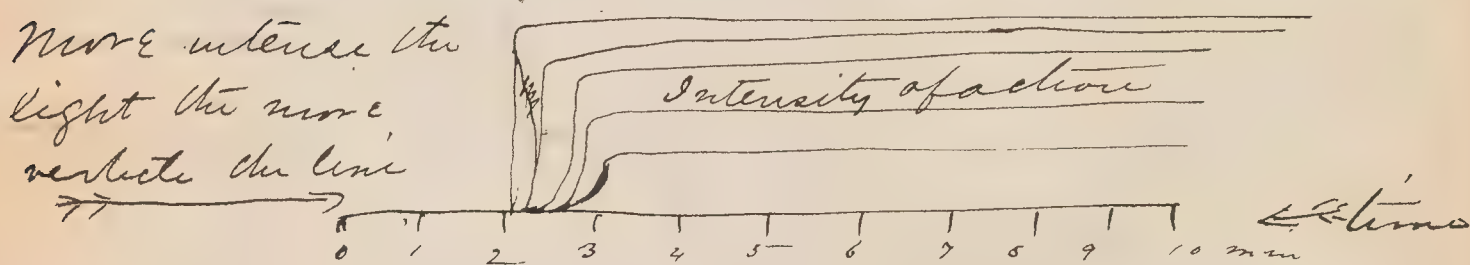
## Photo-Chemical Laws.



Intensity of Chemical action by different lights.

The more powerful the light the more rapid the action - thus

More intense the light the more vertical the line



Upon what does this peculiarity depend? It can be that  $\text{Cl} + \text{H}$  - are converted into an allotropic condition, in which they combine more readily.

Moreover - if  $H + Cl$ . if separated<sup>336</sup>  
& exposed to light - & then brought  
together will not combine with the  
eagerness that is evinced when they  
are exposed to light when mixed.

This proves that an allotropic Con-  
dition is not brought about.

If we use a light of given intens<sup>1<sup>st</sup></sup>  
ity. & constant  $\rightarrow$  the chemical Law  
action (or induction) is proportional  
to the time, (after the light)

If we alter the intensity, the chem-  
ical actions will be increased - <sup>2<sup>nd</sup></sup>  
& indeed directly - with intensity 2 <sup>Law</sup>

the action is double - In. 3. action treble &c.  
that is - the Chem. action is propor-  
tional to the intensity of the light.

If the depth through which the light  
must pass increases in an arith-  
metical proportion & - the action  
decreases in a geometrical proportion.

|                |                 |                  |                   |                    |    |
|----------------|-----------------|------------------|-------------------|--------------------|----|
| 1              | 2               | 3                | 4                 | 5                  | m. |
| $\frac{1}{10}$ | $\frac{1}{100}$ | $\frac{1}{1000}$ | $\frac{1}{10000}$ | $\frac{1}{100000}$ |    |

Action of Foreign Gases The slightest mixture of foreign gases to the induced gases - cause the chemical action to decrease greatly in intensity, Even  $\text{Cl}_2$  &  $\text{H}_2$  not induced diminish the action, This is the simplest kind of Contact action. The kinds of light which influence chemical action, have been determined, accurately for all the parts of the spectrum - & it appears that it is particularly the ~~invisible~~ parts of the spectrum (beyond the violet) probably 2 or 3 times as long as the visible spectrum; the eye however is not able to perceive them although they obey the same laws of refraction by prism as the other rays of less rapidity. These different rays bring about quite different actions - some parts, & particularly the dark rays beyond



the red which give us the heat rays, & the red rays themselves, The yellow rays are those which produce the most lumi-  
nous effect upon us.

Here the chemical action of light is small but it rapidly increases in intensity till it reaches a maximum in the Indigo - decreases slightly in intensity as it advances into the violet, then reaching a second maximum, beyond.

V. in the lavender rays - & then gradually diminishing as it traverses the invisible spectrum.

It may be that chemical action is influenced by the rays beyond the red, but we have only been able to follow its influence within the boundaries mentioned.

We see from this elucidation -

that only a very small part of the spectrum is visible to our organs of sight & that for the greatest part is invisible to us - which rays - follow the same laws of refraction as do the others.

Influence These rays of various rapid-  
ity of vibration both light &  
heat rays - exert & have ex-  
erted the greatest influence up-  
on the form of the earth -  
& its adaptability as the habita-  
tion of Organisms. If the light  
 rays falling on an object are  
 absorbed - or lost, a correspon-  
 ding amount of heat vibra-  
 tions are necessarily produced  
 as an equivalent for that  
 lost. The heat rays too, falling  
 upon the earth & the waters

impart warmth to the former <sup>340</sup>  
while they cause the universal Evaporation of the Water - which  
in its turn is by accidental changes in temperature condensed again & falls to the earth in the form of Meteoric Water (vulgarly called Rain); these waters form our rivers, lakes - & streams - & <sup>have</sup> exert <sup>ed</sup> in all times the most energetic mechanical wearing action upon the rocks of the earth - Carrying down to the sea & into the river deltas - immense quantities of the debris of rocks - thus exerting a constant influence in changing the form of the land - To this mechanical Action - must be added the Chemical Action of the Waters



Ditto

Which, replenish the lost salts of the sea - by dissolving out do from the rocks; - (& by means of subterranean springs & rivers & their much increased temperature this action is intensely energetic - all these actions - which have vastly aided Geological Changes - have been brought about by the heat rays - directly or indirectly obtained from the Sun (& stars). But vegetable life (& to a great extent animal life) is absolutely dependent upon the light rays for assistance - Plants are able, only by aid of the light to decompose CO<sub>2</sub> & assimilate C into the substance of their wood. When light ceases - Plants

Really sleep - & were the light <sup>342</sup>  
altogether to cease - so must Plants  
also vegetative life - for only in  
& with the aid of the light rays -  
can they nourish themselves.  
Animals can nourish them-  
selves in much weaker light -  
than Plants - & are to a great  
extent independent of it. But  
are so much the more depen-  
dent upon the Heat rays.

Many other interesting effects  
of light & heat might be  
mentioned in this connection  
but their consideration be-  
longs properly in the do-  
main of Physics.

---

Lecture 37<sup>th</sup>

Light may too bring about a decomposition in many cases.

$\text{AgCl}$  - is decomposed by light into  $\text{Ag}_2\text{Cl}$ , a black body.

Strong light produces more change that is the change in the degree is proportional to the intensity of the light.

The art of Photography, in our times so important -

Photo- depends upon this fact.

graphy. A paper with a film of  $\text{AgCl}$ , is exposed to light, & according as more or less is cast upon it from the reflecting image, so will the paper be affected, thus the image is formed, the processes of preparing & improving ditto - are too technical.



Cl. Does not combine with C  $\text{Cl} + \text{O}$ .  
 directly, nor with O. If there -  $\text{H. C} + \text{C}$   
 for a Carbon Hydrogen compd  
 is brought into Cl. the H Exp  
 Combines with Cl - & the Carbon  $\searrow$   
 separates (Turpentine in Cl)  $\leftarrow$   
 If a candle is brought into Cl  
 neither C nor O - combines, but  
 only H. the resulting compd  
 is HCl (test its acid properties) Exp  $\leftarrow$   
Cl + P -

We can bring about a com-  
 bination between Cl & P. there  
 results by this action 2 Comps  
 When Cl is in Excess - there is  
 formed a solid body -  $\text{PCl}_5$  -  
 If P is in excess a liquid  
 is formed =  $\text{PCl}_3$ , Comb. at ord. temp.  
 As & Sb. in finely divided state  
 combine at ordinary temper-  
 atures -

~~33~~ → All these combustions  
 are brought about at  
 Ordinary temperature - a  
 distinction to be noted; as  
 this is one of the features that  
 distinguish Cl. from O.

The Metals can  
 also be combined with Cl.  
 but most by higher temper-  
 ature - Cu wire - must be  
 heated, then combines.

Cu  
Ox →

If Cu is very finely divided  
 (Cu leaf) it combines at  
 ordinary temperatures. By  
 bringing a large mass of Cu into  
Explain compar. small surface into Cl  
 no action takes place (just as in  
 trying to light the solid part of  
 a candle); but increasing of surface  
 is increasing amt of chemical force

These metals burn with a  $\text{Cl} + \text{Na}, \text{K}$  greatly more intense flame, Care. than these other bodies -

Na - must be heated -  
to combine - then burns with  
an intense yellow flame Exp  
Cl dissolves  
in  $\text{HO}$  a (~~Chemical~~) solution,  
the solution has a yellow color,  
in the dark it is totally un-  
alterable & may be kept for  
years - In the light, how-  
ever - it is soon decomposed  
into  $\text{HCl} + \text{O}$



If there is a body present in  
the solution, which has an  
affinity for Oxygen - the decom-  
position is brought about, Predispo-  
without the aid of light. ring  
affinity



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For example,  
 $MnO \xrightarrow{CO_2}$   
 $HCl \xrightarrow{CO_2}$

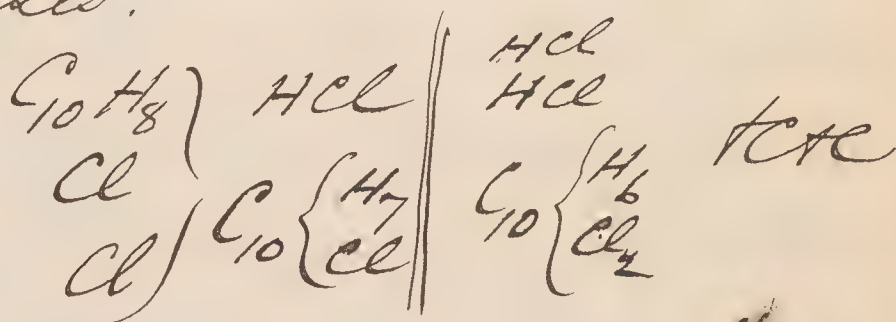


( $MnO$  to  $MnO_2$ )

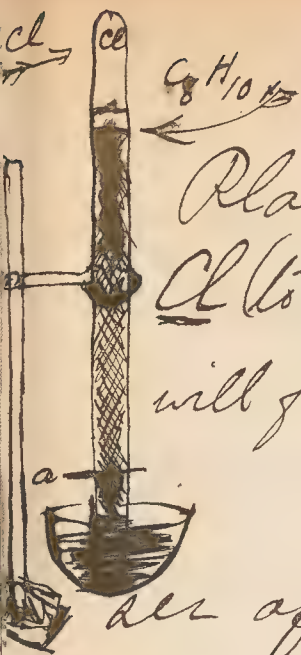
$\xrightarrow{CO_2}$

A black precipitate of  $MnO_2$  is formed from  $MnO$ .

$Cl$ , acts here as an ~~substituter~~ substituter of  $O$  - in all these cases.



Here  $Cl$  acts as the substituter of  $H$  - but this only occurs to a certain extent, in the light more atoms of  $Cl$  are substituted for  $H$ , than in the dark, but even in the light the substitution can only be partially effected - some  $H$  atoms will still remain.



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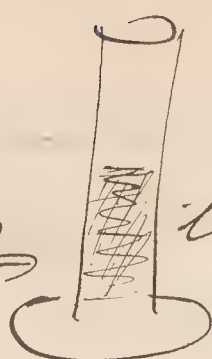
Place in a tube above  $H_2O$  some Cl (to a) a small amount of  $C_8H_{10}$  will form  $HCl$ . -  $H_2O$  will rapidly rise Exp

Cl. acts as a decomposer of Chemical Compounds, in two ways - first. by Oxidation - + second. by Substitution - In the second way mostly, the bleaching of vegetable colors - + of dyes.

If litmus paper be brought into dry gas (Cl) <sup>about</sup> no bleach. Exp is brought - but when  $H_2O$  is present, the bleaching is done instantly. Here an Oxidation is the Cause of the bleaching. Hence Water is always a necessary accompanier of any bleaching process with Cl.

Exp

Indigo



Bring into Indigo -  
Ink + Lacmus. solu-

tions Chlorine Water +  
show the instant bleach-

Exp

ing. Bleach Cotton goods  
by Chlorine Water.



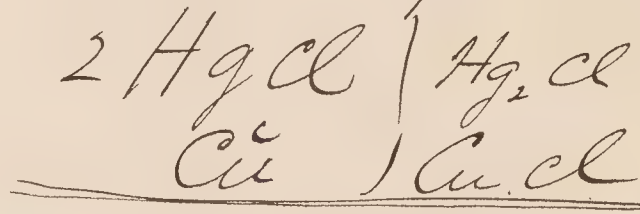
Ink, + the  
above mentioned coloring matters  
of vegetable extraction! can be  
thoroughly bleached by Cl.  
Printers ink, on the contrary,  
contains much Lampblack -  
(C) and we have already seen  
that Cl + C cannot unite  
+ are indifferent to one another  
Hence printed paper will <sup>not</sup> be  
bleached white in Cl H<sub>2</sub>O, but  
written matter - with ink -  
will be attended to most  
thoroughly by ditto - Perform  
the Exp.

Exp



To produce Cl compounds we would not bring the <sup>To form</sup> body to be combined in a Chlorides cylinder of Cl, but would proceed just as in the case of O - either bring the body in a tube over a stream of Cl, or - bring it into contact with some substance that gives up its Cl. These compounds are sometimes salts sometimes fluids or gases. They have the power of combining again among themselves, just as the Oxygen compounds (BaCl, CdCl). The platinum group, of Chlorides are the most important, of all these Double Chlorides -  
 KCl, PtCl<sub>2</sub> - NH<sub>4</sub>Cl RbCl<sub>2</sub> -  
 RbCl, PtCl<sub>2</sub> - CsCl, PtCl<sub>2</sub> etc

A substance which gives off its Cl easily & is after used for producing Cl compounds - is  $HgCl$

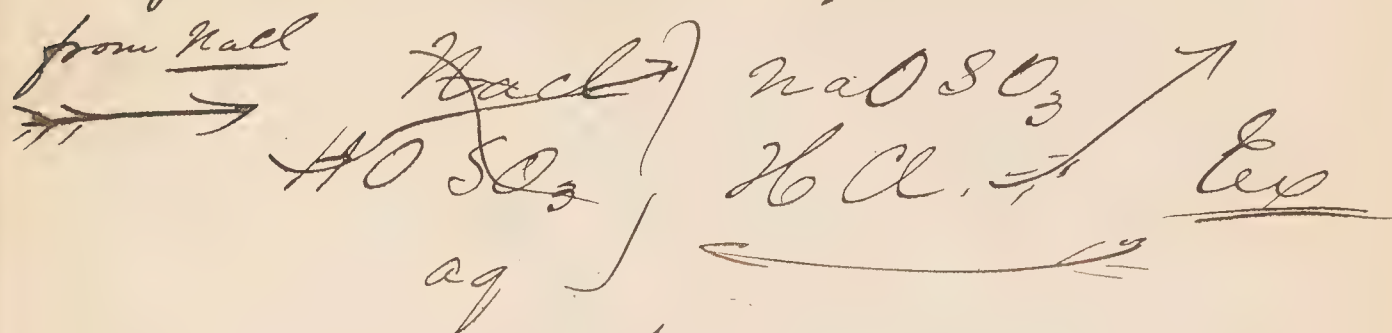


$HCl$

Hydrochloric acid

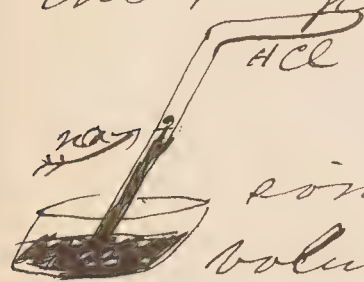
Comes free in nature - particularly in the neighborhoods, of active volcanoes, where it forms itself just as as we manufacture it in the laboratory, namely by <sup>the</sup> acting upon a Cl compound with a strong acid. Cl compounds in the presence of a stronger acid give up their Cl which then unite with the Hydrogen of  $H_2O$  to form  $HCl$ , & an oxy salt is formed. instance on next page.

We generally manufacture Hydrochloric acid as follows



If we bring substances (Elements) into contact with  $\text{HCl}$ , many combine with it at ordinary temperature,

$\text{Na}$ ,  $\text{K}$  &c. in fact the metals of the first four groups, have the property.



Bring above  $\text{Hg}$  some  $\text{HCl}$ . (a measured volume) if, now - a

piece of  $\text{Na}$  - is brought up - on a wire - to the surface of the  $\text{Hg}$ , the combination will take place at the ordinary temp. & the  $\text{Hg}$  will rise.

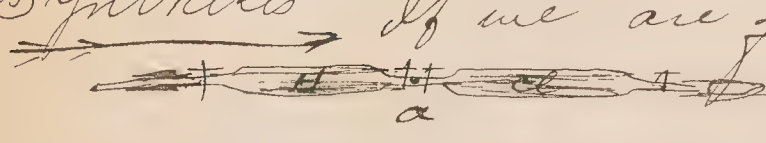
Exp



353 had

If we measured the  $HCl$ , in the tube, this method would

Analysis be an admirable one to analyze the gas. The Na. combines with Cl, & leaves the H. This unabsorbed gas volume could then be measured, (& reduced), & the composition of  $HCl$  determined. We would find that exactly  $\frac{1}{2}$  of the volume would disappear. That is ~~is~~ one volume of  $HCl$  is composed of  $\frac{1}{2}$  vol.  $H$  +  $\frac{1}{2}$  vol's  $Cl$ . The specific gravity of the gas is now in our hands & its atomic weight.

Synthesis  If we are furnished with 2 tubes of exactly the same volume, & place in one H, in the other Cl, & allow them to diffuse into one another by opening the cocks at a, & allow them to be in the light, they will combine.

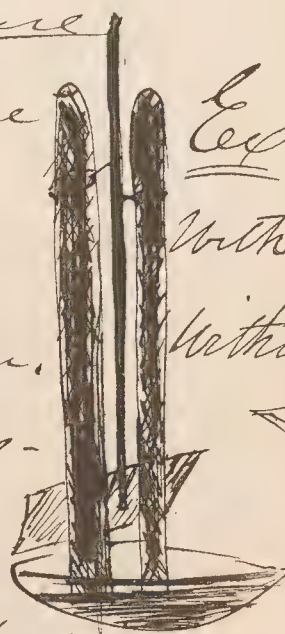
# Properties.

a colorless gas, of a pungent odor, opened to the air - it gives out thick white clouds. Its specific grav = 1.2474 (Air = 1)

It is a strong acid - (show its acid properties + its sp. gr. Exp. -  
15)

in 1 exper.) Under a pressure of 30 or 40 atmospheres it is condensible. Has an immense

affinity for Water, H<sub>2</sub>O. Takes up 464 times its own volume of the gas. Is the gas pure the absorption takes place instantly, + with great violence so that glass vessels may be broken. If a bubble of air is present - the absorption takes place more slowly - If the two absorptions are performed side by side, it will be plainly observed.



Exp. -  
With +  
Without air.

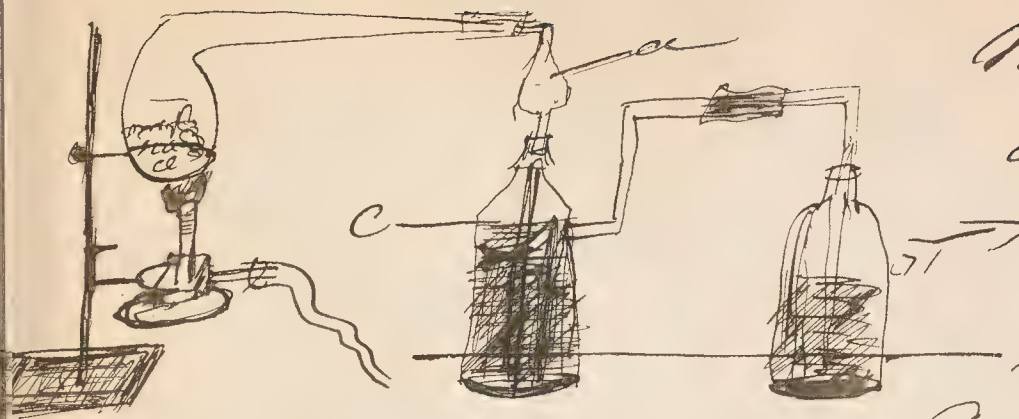
It is no supporter of combustion  
Exp a taper is extinguished.

Brought into contact with  
 Oxides - (with heat) the HCl  
 is decomposed & a Cl compound.

Exp BaO } BaCl is formed together  
 HCl } H<sub>2</sub>O or with H<sub>2</sub>O.

Analogy  
to H<sub>2</sub>O The closest analogy exists  
 between HCl + H<sub>2</sub>O, for all  
 the decompositions of the one  
 are allied to those of the other.  
 Those metals which decom-  
 pose H<sub>2</sub>O at ordinary temp.  
 decompose also HCl, namely  
 K, Na &c. Those that decompose  
 H<sub>2</sub>O in presence of an acid, de-  
 compose also HCl. (HCl is an acid  
 hence they decomp. it alone) Those  
 which do not decompose H<sub>2</sub>O at all  
 will not attack HCl (an. Rt &c)





Manufacture  
of the gas.

As the

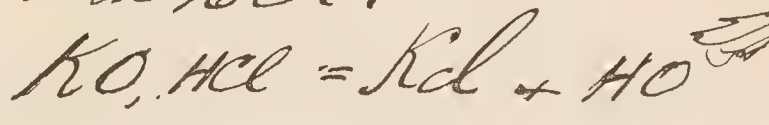
gas is so eagerly absorbed by  $H_2O$ , it is necessary to take special precautions that the gas shall flow into the water faster than the absorption can take place. otherwise the fluid will flow back into the retort, Hence special arrangements must be made, & we combine 2 or 3 flasks with connecting tubes together, & furnish the first flask with a safety bulb, large enough to contain all the fluid in flask 1. (The flasks should only be filled to the level b. & not, as in the figure, to c).

Lecture 39<sup>th</sup>

If we distill a saturated solution of  $\text{HCl}$ , some of the gas will be lost, that is more  $\text{HCl}$  distils over than Water. until at last - a point is reached where the  $\text{H}_2\text{O}$  & the  $\text{HCl}$ , both distil over equally - a constant Boiling point, exist at  $109^\circ$ .

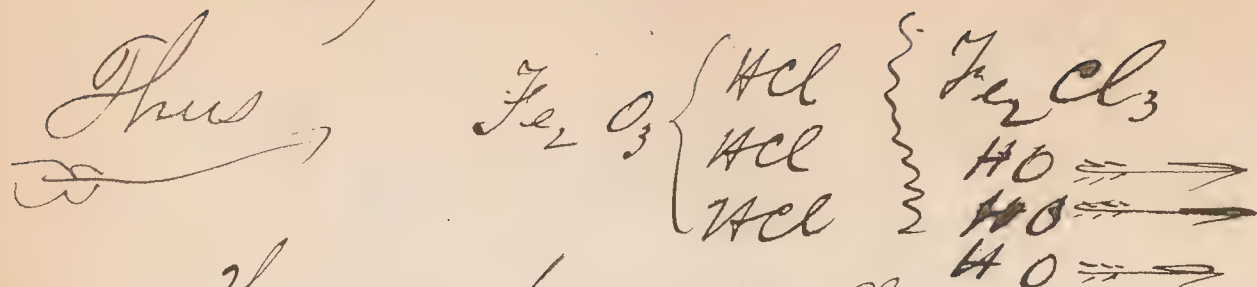
This indicates not that at  $109^\circ$ , a determinate compound is formed - for it has been found that at different pressures different constant Boiling points are found - & diff. Sp. Gr. If we place more  $\text{H}_2\text{O}$  to a boiling ( $105^\circ$ )  $\text{HCl}$  &  $\text{H}_2\text{O}$  more  $\text{H}_2\text{O}$  distills over than  $\text{HCl}$  till the Sp. Gr. is reach. & over more

As from Chlorides we always use the liquid  $\text{HCl}$ . We can bring the Oxides all to Chlorides by bringing them into Contact with  $\text{HCl}$ .



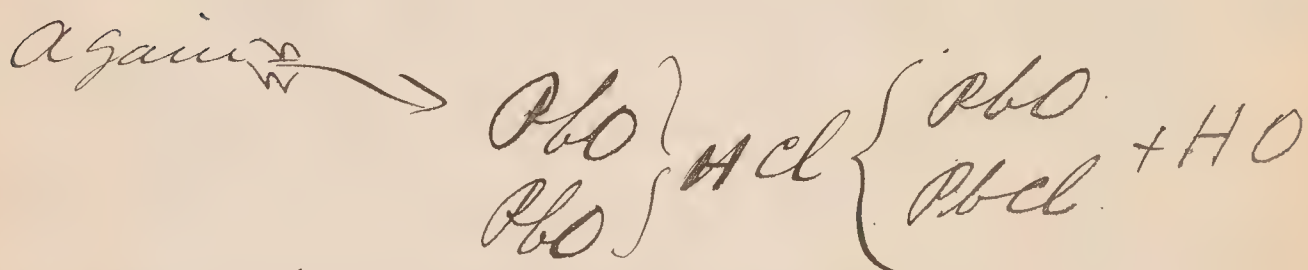
So in all cases, an atom of oxygen is replaced by an atom of Chlorine, while the  $\text{H}$  set free combines with the  $\text{O}$  in statu nascendi, from the base. The rule is that for every atom of water formed - an atom of Chlorine goes into combination with the Metallic Element to form an atom of Chloride. and generally it is that Chloride brought about which corresponds to the decomposed Oxide. be it a protoxide a protochloride is formed, a sesquioxide - a sesquichloride is formed or





The corresponding Chloride is formed.

If the Oxide be given as we can. (if such a compound has any existence) always by bringing it into contact with so much HCl, as is necessary to form the corresponding Chloride - bring that Chloride about. see above.



Oxy-Cl. If we bring too little chloride rides. to play - Oxychlorides are formed as above.

If we bring an excess - the excess over what is necessary to form the corresponding Chloride remains in solution as HCl & H<sub>2</sub>O

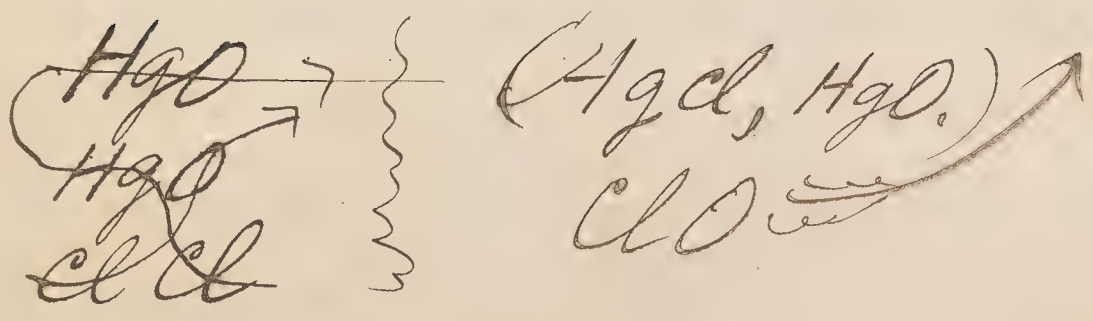
~~Perform the precipitations & describe the properties of AgCl & PbCl.~~

Compds of Cl + O.

- 1<sup>st</sup> Comp.  $ClO$  = blue  $HClO$  known
- 2<sup>nd</sup> "  $ClO_2$  " "
- 3<sup>rd</sup> "  $ClO_3$  " "
- 4<sup>th</sup> "  $HOClO_2$  - only known with  $H_2O$ .
- 5<sup>th</sup> "  $HOClO_3$  - - - -

It is singular that so many compounds of  $Cl + O$ , exist when it is impossible to produce a direct combination of  $Cl$  with  $O$ .

$ClO$ .

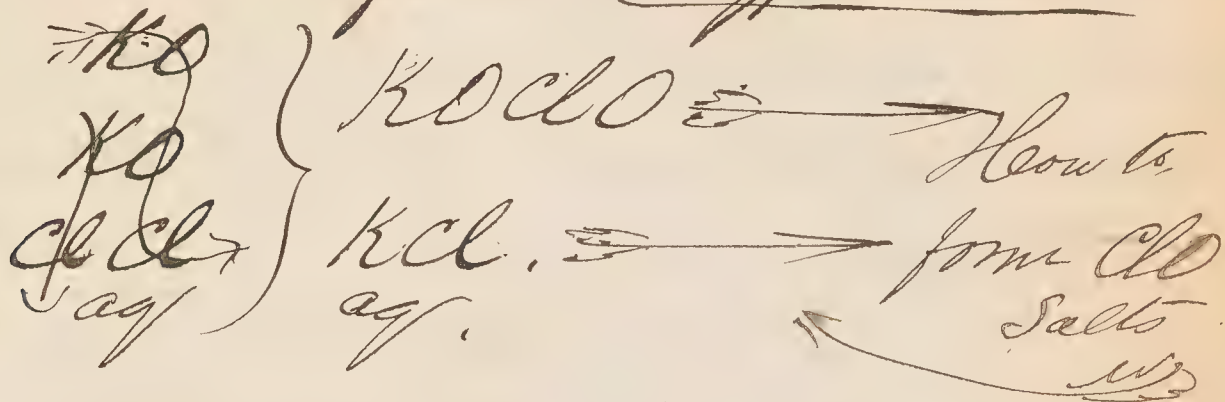


The compound however is so unstable, & falls apart into its constituents so readily - that an explosion may take place from the most trifling cause; may even take place without apparent cause. Hence it is too dangerous to manufacture in the lecture room. It is a red brown gas, penetrating odor. Can be condensed into a red. brown liquid, frequently falls apart - by itself into  $\text{Cl} + \text{O}$  - with explosion.

By shaking  $\text{Cl}$  Water with  $\text{H}_2\text{SO}_4$  we can form  $\text{ClO}_2$  in  $\text{H}_2\text{O}$ ,  $\text{ClO}_2$  - forms many salts. but all partake of the unstable nature of the  $\text{ClO}_2$  contained in them, and hence cannot be kept for any time but fall into Chlorides.



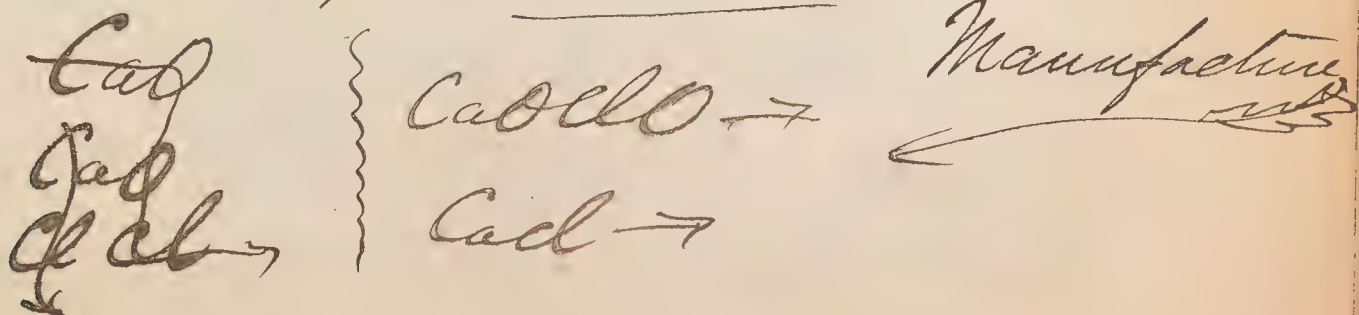
If we let Chlorine act upon strong bases we can form Hypochlorites



These salts can be used with much more advantage for bleaching than ClO itself. KCl always present - cannot be separated

The most important Hypochlorite (Chloride of Lime). Has a very extensive use in man. CaOClO manufacturing, & technical chemistry.

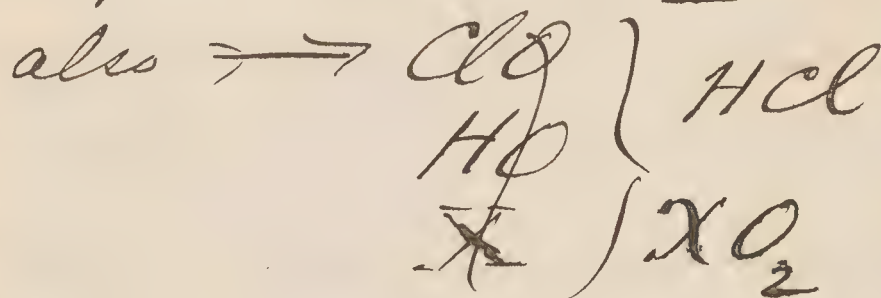
It is universally used in bleaching Cotton goods, Formed by letting Chlorine act upon CaOH



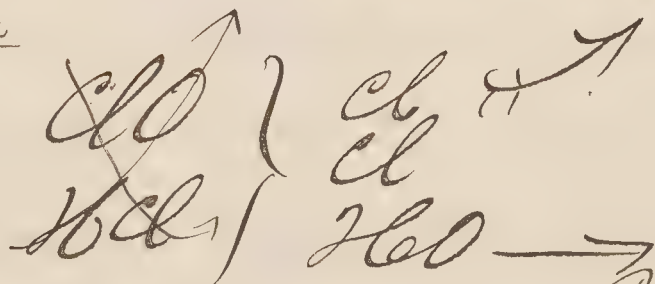
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Action  
of  $\text{ClO}$   
Salts

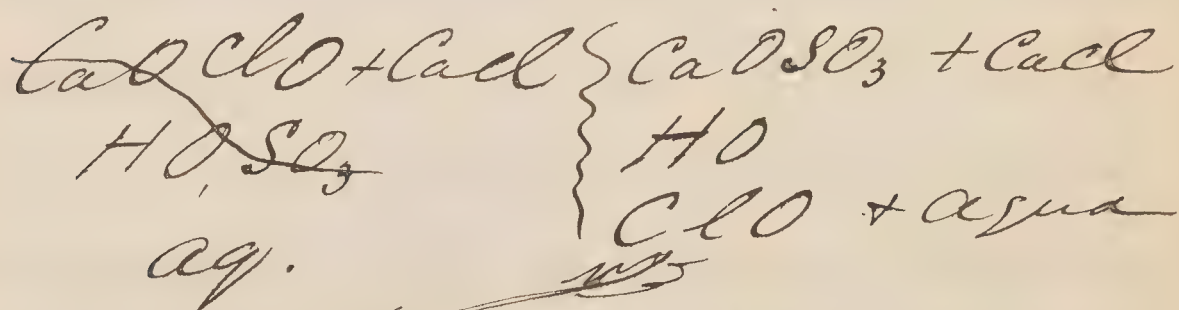
$\text{ClO}$  is an exceedingly strong  
Oxidizing substance, its  $\text{O}$   
is given up - + if  $\text{HO}$   
is present the  $\text{Cl}$  oxidizes



Again



Or with Bleaching Powder -



This  $\text{Cl}$  if  $\text{HO}$  be present acts  
thus  $\rightarrow \text{Cl} + \text{HO} = \text{HCl} + \text{O} \rightarrow$

Hence two atoms of  $\text{O}$  are given  
off + Oxidize with eagerness.

For so important a class of salts as the Chlorides - it would seem necessary to have some sure + easy means of detecting them - & fortunately we have.

In this detection there is one general practice in practical Chemistry - & that is to bring about, by some compound - Reagent which we call a Reagent - some Characteristic Compound, which in each case infallibly informs us of the presence of Chlorine, or of any other body for which we may be testing.

There are three general reagents, which we generally use to detect acids or Halloids, in their compounds or alone.

& we will proceed now to notice the behavior of  $HCl$ , or



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Test of  $HCl$  of some Chloride with these three. They are

|               | $AgNO_3$                                                                                                                                                                    | $PbO_2$                                                                                                                                   | $BaCl$                                                                                                                           |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| $\rightarrow$ | $HCl \rightarrow$<br>$AgNO_3$                                                                                                                                               | $HCl \rightarrow$<br>$PbO_2$                                                                                                              | $HCl$                                                                                                                            |
| $\rightarrow$ | $HONO_2 \rightarrow$<br>$AgCl$                                                                                                                                              | $HCl \rightarrow$<br>$PbCl$                                                                                                               | $BaCl$                                                                                                                           |
| $\rightarrow$ | $\downarrow$<br>$AgCl$ is sol.<br>in $NH_4O$ - +<br>reprecipitated by<br>$HONO_2$ - + is turned<br>black on exposure<br>to light,<br>by these prop. it<br>can be recognized | $\downarrow$<br>$PbCl$ is<br>reprecipitable<br>only from<br>concentrated<br>solutions, that<br>is - $PbCl$ is<br>soluble in<br>much $HCl$ | Nothing<br>There could only<br>be formed<br>$BaCl + HCl$<br>but both<br>are already<br>formed, hence<br>no action<br>is produced |

These reagents we shall use to detect all the monovalent salt formers.

## Lecture 40<sup>th</sup>

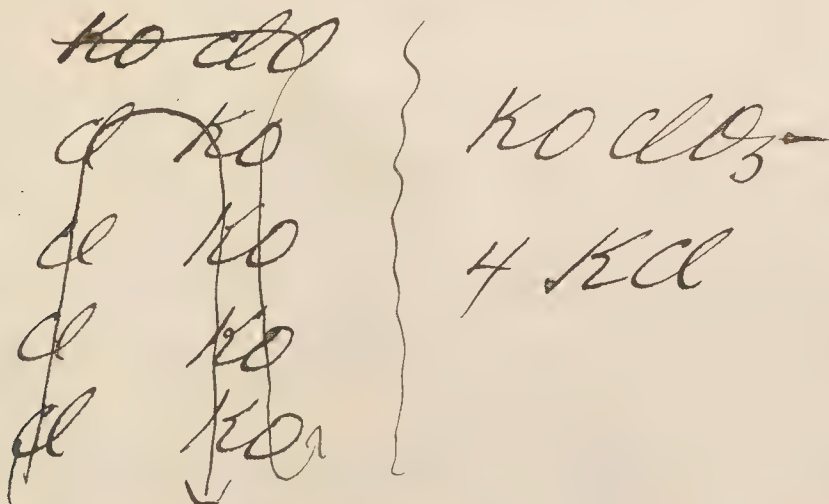
There is no crystallizable salt of  $\text{ClO}_2$ , + all of them are mixed with Chlorides which cannot be separated. They in their oxida-

tions generally give us super oxides

$\text{MnO} + \text{HO} + \text{KOCLO} = \text{MnO}_2 + \text{c.}$  Ex  
 Indigo solution is  $\downarrow$  entfärbt.



It may be produced by the Oxidation of Hypo-Chlorous Acid.



In a very alkaline solution

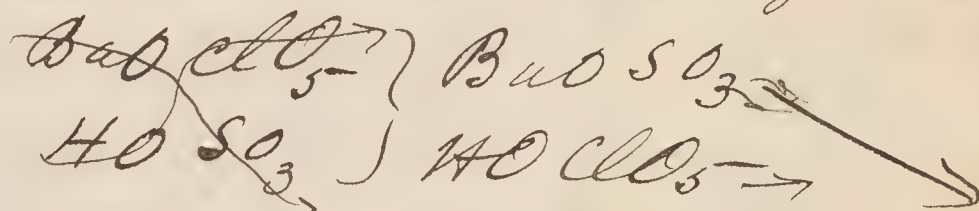
By leading pure Cl. in the  $\text{KOCLO}_3$  sol. we oxidize it to  $\text{KOCLO}_3$ . (Separate KCl by crystallization.)

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From the  $K_2O ClO_3$  we can separate the  $ClO_3^-$  -

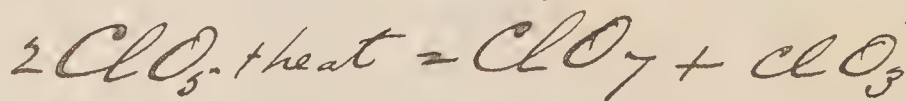
By forming  $BaO ClO_3^-$  +  
then separating  $BaO$  by  $SO_3$

Separation  
→



It is a clear, non-  
forming liquid - by ~~concentrating~~  
heating the acid becomes more  
concentrated -  $H_2O$  alone distills  
but when, a sufficient con-  
centration has been reached;

Decomp. it is decomposed into  $ClO_7$   
+  $ClO_3$  - or the lower oxides of  
 $Cl$  - thus <sup>in solution</sup>



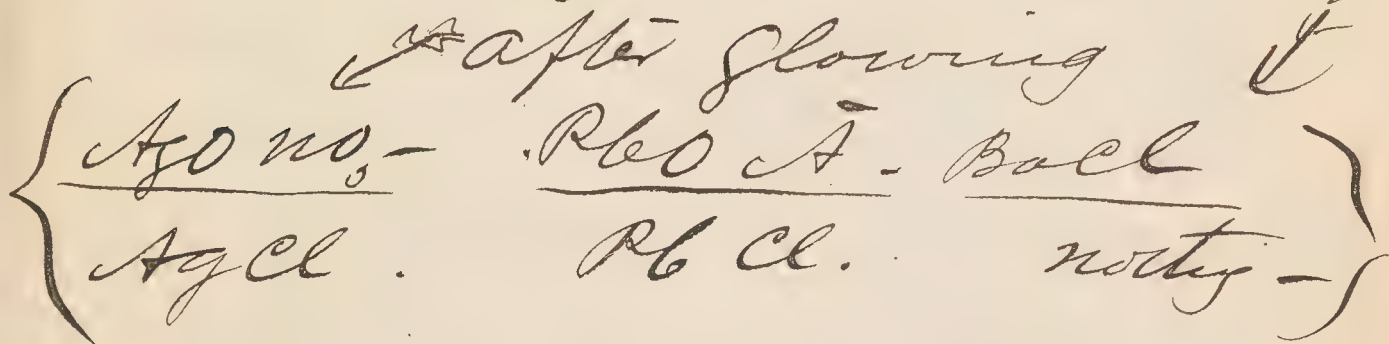
Forms with bases an exceed-  
ingly crystalline salts, but  
none are insoluble in Water  
Hence with its Reagents -  
we use - no action results



But the chlorates have one re-Test action which is characteristic for for them:—namely. that by  $\text{ClO}_3$ -  
 glowing them they give off all their Oxygen, & a chloride remains behind. & that then the reactions of Chlorine will be obtained.



After glowing



Thrown upon coal (burning) they puff up - They Exp give up their oxygen so readily - that if  $\text{ClO}_3$ - salts are mixed with any substance having affinity for Oxygen - the lightest Exp blow will bring on an explosion. for example

Ex

Mixed with  $\text{S}$  upon an anvil a blow with a hammer will give a violent explosion. Used - for Detonating Powders (Caps) - Cannot be used for Gunpowder on acct of its instantaneous explosion throughout the mass. With  $\text{SO}_3$  (cond.)

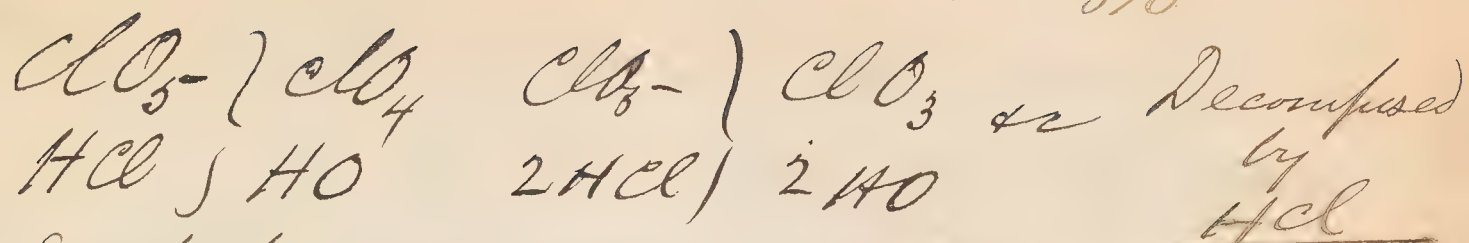
Ex

Mixed with  $\text{ClO}_2$  salts give off a yellow gas (a lower Oxide of  $\text{Cl} + \text{O}$ ) - & is often attended with explosion. If a burning body is near it & explodes.

Ex.

Mixture of  $\text{KClO}_3$  + Sugar & a drop of  $\text{SO}_3$  explode - formerly matches were made in this way -

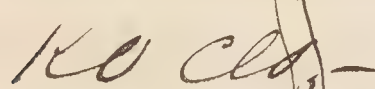
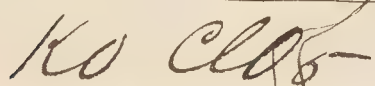
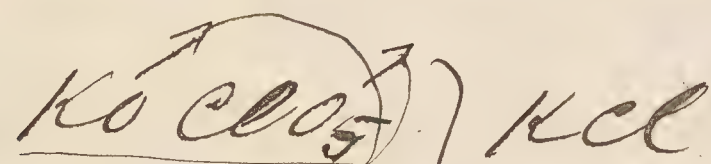
With  $\text{HCl}$  - the most various decompositions of  $\text{ClO}_2$  salts



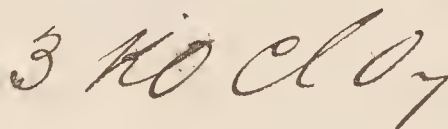
So that every atom of ~~Chlorine~~ Oxygen  
can be substituted + Cl given off.



Manufactured  
from  $\text{ClO}_5-$  by Oxidation.



heat



Manuf.  
of



A portion of Oxygen is given  
off. + the mass becomes  
somewhat liquid, this point  
is the one at which most  $\text{ClO}_5-$   
is formed, by Crystallizing the  
 $\text{KO ClO}_7 \rightarrow$  is separated in crys-  
tals - as the salts of  $\text{ClO}_7$  with KO  
is differently Soluble.



From this salt we can obtain  
 $\text{HClO}_2$  - + these salts are sin-  
 gularly the most stable com-  
 pounds - of Cl & O. <sup>(Crystallized)</sup> It distills

Prop-  
 erties  
 of  
 $\text{ClO}_2$   
Salts

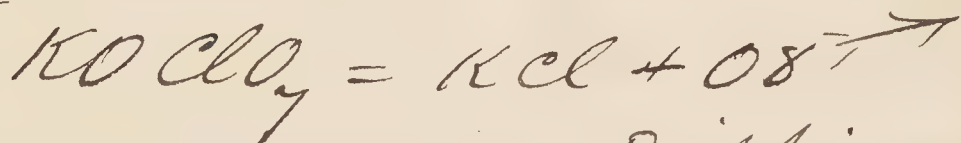
at  $110^\circ$  + condenses in  
 needles in the neck of retort.  
 By bringing Hydrofluosilic-  
 ic Acid to  $\text{KClO}_2$  - we  
 can become the  $\text{HClO}_2$   
 by itself. At Higher temper-  
 ature than  $110^\circ$  it is ~~decom-~~  
~~posed~~ obtained as a compd of  
 $\text{HClO}_2$ . A colorless fluid  
 not frozen at  $-40^\circ$ . This conc.  
 acid is dangerous: if we  
 drop it upon a combusti-  
 ble body (as wood), a violent  
 combustion takes place.  
 Under  $110^\circ$  it distills over as  
 $\text{ClO}_2, 2\text{H}_2\text{O}$ ? alone as a compound  
 $\text{ClO}_2, \text{H}_2\text{O}$ ?

At ordinary temp

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With  $\text{As}_2\text{O}_3$  it is not note  
decomposed - as  $\text{ClO}_2$  - Distinction

No precipitates by the reagents  
generally used. But like  $\text{ClO}_2$ -  
by flowing it gives off all  
its  $\text{O}$  + a chloride remains

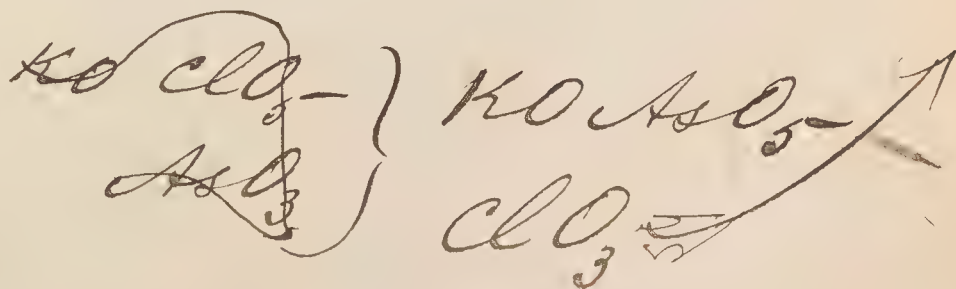


Difficultly  
decomposable with  $\text{Zn Cl}$ .

With Sulphur mixed  
it explodes with more violence  
than  $\text{ClO}_2$  salts.



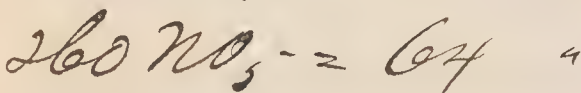
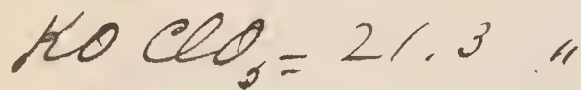
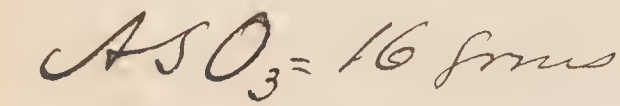
From  $\text{HOClO}_2$ -  
by allowing  $\text{KClO}_2$  to act upon  
 $\text{As}_2\text{O}_3 \Rightarrow$



Dangerous to manufacture in  
large quantities on acct of instability

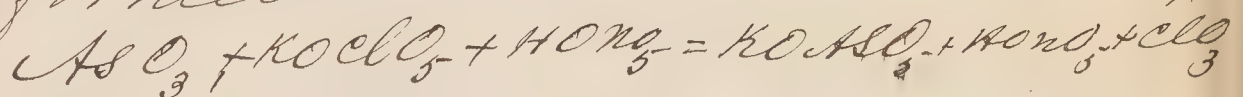
ClO<sub>3</sub>  
 Proportions in which to mix ingredients

On acct of this inconvenience it is best to observe a certain mixture of ingredients by which to manufacture it.



AsO<sub>3</sub> reduces NO<sub>3</sub> to NO<sub>3</sub> - + NO<sub>3</sub> reduces ClO<sub>3</sub> to ClO<sub>3</sub> - (AsO<sub>3</sub> - KCl)

is formed.



Unstable May suddenly be decomposed by itself into

Cl + O<sub>3</sub>

In the light these explosions can as easily explode.

A spark of wood decomposes it in the dark with

a weak explosion -

into Cl + O<sub>3</sub> -


Exp



The analysis of the gas may thus be carried out.

Bring upon a frame of wood




 a tube of thick glass with  $\text{ClO}_3$  - expiende it over a gentle heat - of the lamp - & bring the resulting  $\text{Cl} + \text{O}$  - into a apparatus to measure it - & it will be found that  $\Rightarrow$

Analysis

On a measured vol,

4 volumes  $\text{ClO}_3$  give us 5 vols.

that is; the comp'd - increases in volume  $\frac{1}{5}$ th of the whole -

If the gas is opened under a solution of  $\text{KO}$ , the  $\text{Cl}$  is absorbed &  $\text{O}$  remains behind -

We find that we have Exp

2 vol  $\text{Cl}$

3 vol  $\text{O}$

4 vol  $\text{ClO}_3$

or  $\longrightarrow$

De

4.880. = 2 vol  $\text{Cl}$

3.318 = 3 vol  $\text{O}$ .

8.198 = 4 vol  $\text{ClO}_3$

2.049 = 1 vol  $\text{ClO}_3$

2 vol  $\text{Cl}$  =  
1 Equivalent.

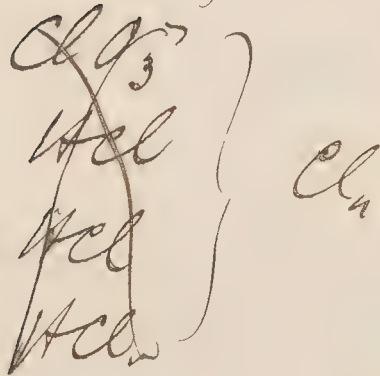
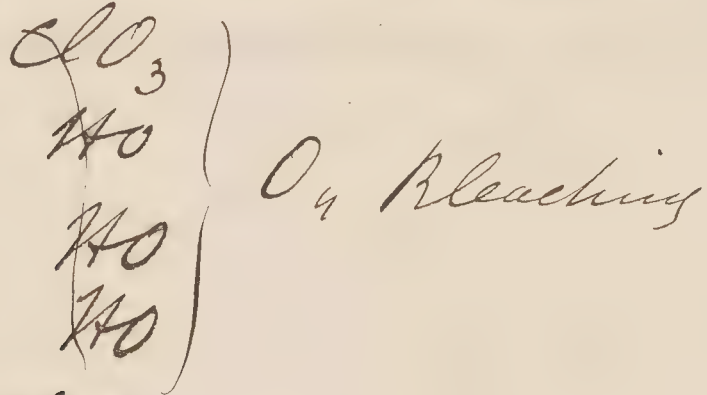
3 vol  $\text{O}$  =  
1 Equivalent -

$\therefore$  Equivalent  
Compos. of Comp'd -  
=  $\text{ClO}_3$

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With  $PbO$  it gives a crystallizable salt.

Strongly bleaching power.



With Phosphorus

if it is brought into contact with  $ClO_3$  a violent explosion & combustion ensues.

Exp

## Lecture 41<sup>st</sup>

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### $\text{ClO}_4$ .

Is neither an acid nor a base  
is a strong oxidizing agent,  
like all the other compounds  
of  $\text{Cl} + \text{O}$ , & it forms no salts  
in this respect resembling  $\text{NO}_3$ .

It is very unstable & liable  
at any time to fall apart into  
 $\text{Cl} + \text{O}$  (sun light & heat)  
Manufactured by acting manufac  
ture  $\text{KClO}_5$  by  $\text{SO}_3$  concen. - highly  
dangerous to manufacture.  
It serves us to distinguish between  
 $\text{ClO}_5$  &  $\text{ClO}_7$  salts. For treated Prop-  
with conc.  $\text{SO}_3$  -  $\text{ClO}_5$  salts give erties  
off this gas at ordinary temps.  
 $\text{ClO}_7$  salts only on being heated.  
In the presence of Organic  
matter it explodes even in  
loosed conditions with violence.



Brom.

Presents the most striking analogy to Chlorine, all that has been said of the former maybe re-  
For/From- men stated here. It comes in nature under the same conditions as Chlorine. In the waters of seas, Springs - Sea plants - where ever Cl is, so, too Br. But, never where

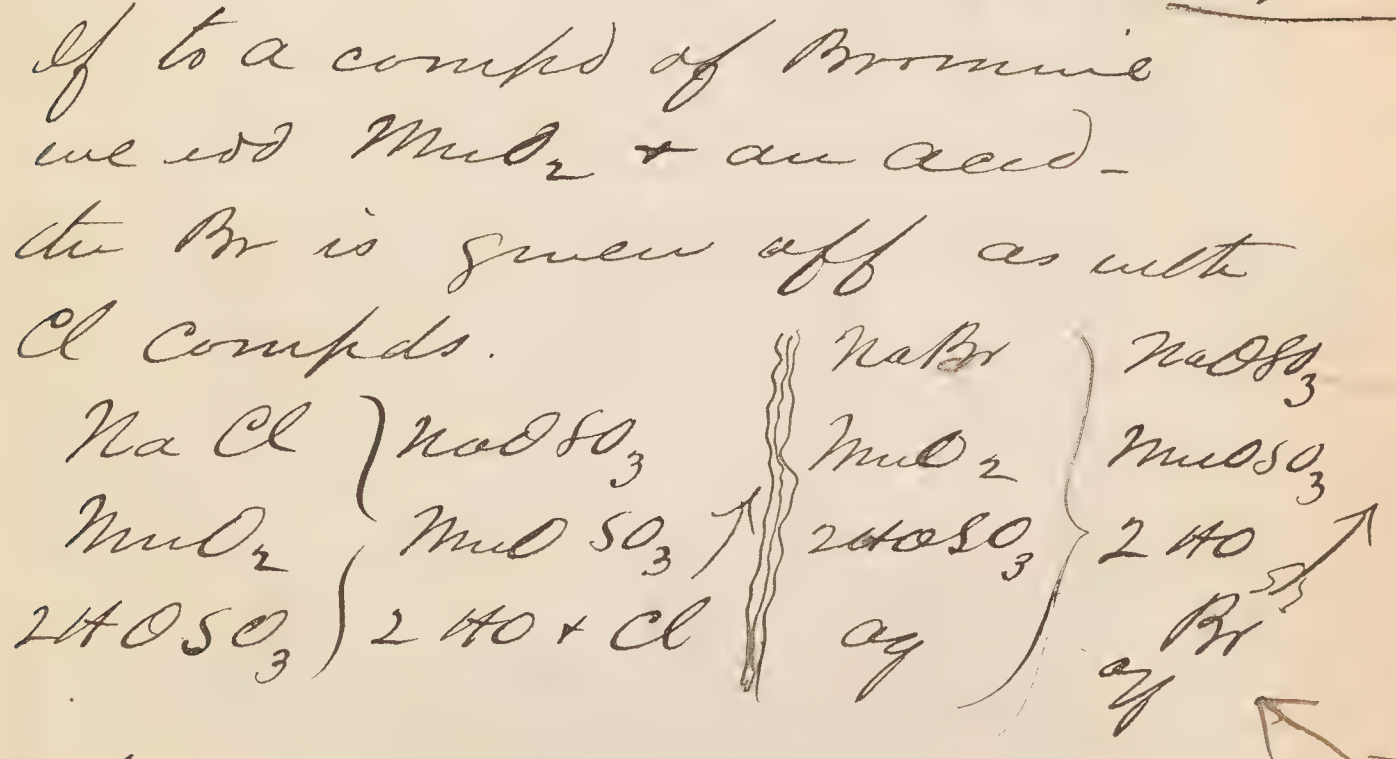
Cl + Br compds occur together does the Br. exceed the Chlorine.

Manufactured from the Mother liquid of Mineral  
Manuf. acture Waters or Springs; of the waters of the Dead Sea.

If we wish to test for the presence of Bromine we proceed as follows.

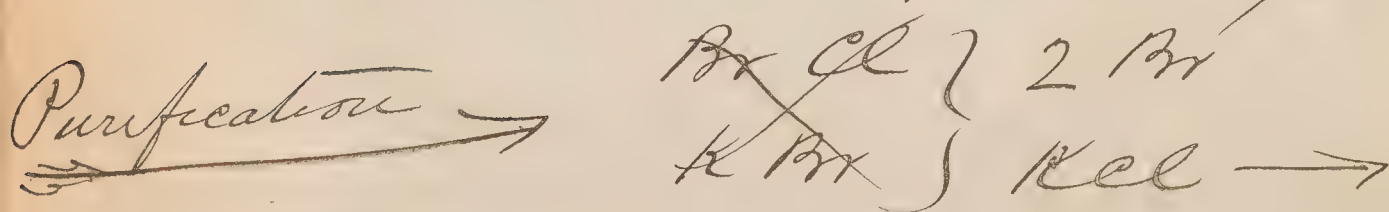
Tests Brom. distinguishes itself from Chlorine, in the life en.

ergetic affinity than Cl.  
 Hence if to a compound con-  
 taining Br. we add Cl, tho Exp  
 the Cl - replaces Br - & Bromine  
 is separated, & for each atom of  
 Br separated from the Compd - Method  
 an atom of Cl - takes its place, of An -  
 Hence this gives us a means of → alysing.



The Bromine having a lesser af-  
 finity than Cl for its compounds  
 it is by this means <sup>that we</sup> - afman -  
ufacture it it distills over first  
 the Chlorine does not dis - Character

until much later - so that  
 by keeping the first portions  
 (Technical) of the distillate, we obtain  
 manufac. Br. in a tolerably pure state.  
 Purification will be mentioned.  
 As Br is somewhat volatile  
 it is condensed in KO solution,  
 it forms the same Compd as  
 the corresponding Cl, comp'd,  
 ( $\text{K}_2\text{BrO}_5$ ,  $\text{KBr}$ ); by heating  
 similarity this compound - we obtain  
 to  $\text{Cl} \rightarrow \text{KBr} + \text{O}^{\rightarrow}$ . (If condensed  
 in the distillation by cold  
 it can be obtained as Br. fluid)  
 Is generally mixed or lvs  
 Cl with it. By distilling  
 again with  $\text{KBr}$  it can  
 be obtained pure.





## Properties

As thus obtained Br- is a deep reddishbrown liquid, of a horrible odor. Specific grav. at  $0^{\circ} = \underline{3.1872}$   
 Equivalent = 80. - At ordinary temp. - somewhat volatile.

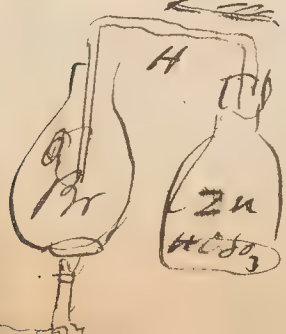
A drop scattered in a jar will fill it shortly with fumes.

Exp.

More poisonous than Chlorine. Inspired it acts not only destroying to animal tissues but acts directly poisonous.

All the combinations that are brought about by Cl can be repeated by Br. but all Exp. of them take place with less energy, & by increased temperature. So H + Br do not combine at ordinary temperatures but at higher

Send a stream of H after lighting it - into Br vapor.



C. does not combine under any circumstances with Br just as with Chlorine.

Ex  $\nearrow$  Cu in laterally solid state combines less strongly than with Cl - after heating -  
 $\searrow$  Foil - hardly gives an emission of light - while at ord. temp's w Cl it burns instantly -

Ex  $\nearrow$  Phosphorous - combines at ordinary temperatures, but not with the same energy -  
 $\searrow$  As - does not combine at ordinary temp's with Br - they do with Cl.

Na K Cu. Sr. Ba - are the only metals that do combine with any thing like the Energy - that they combine with Cl. at ordinary temp's -

We have discovered by these Results  
 Experiments that precisely the of our  
 same combinations that we can Combust-  
 bring about with Cl + the other known  
 Elements <sup>we</sup> can also bring about  
 between them + Br - only with the  
 unusual difference that in these  
 latter cases the combinations are weaker,  
 Br dissolves also in H<sub>2</sub>O - at  
 higher temp. - it is less + less Br, H<sub>2</sub>O  
 dissolved - decomposed like Cl H<sub>2</sub>O  
 + by the same Causes. Br H<sub>2</sub>O is  
 likewise a strong oxidization  
mittel - like Cl H<sub>2</sub>O, but as with  
 energy after action + analogy  
<sup>of Br</sup> ~~with Cl~~ - with less energy than  
 Cl. Ink - ~~Indigo~~ Indigo solu-  
 tions &c are likewise rendered. Exp  
 ed colorless by the Oxidizing  
 force of Br - just as with  
 Chlorine water.



$MnSCl_2$  Just as with  $Cl$ , but with less  
to  $MnO_2$  energy. The salts of  $MnO$ -  
are Oxidized to  $MnO_2$  - but  
more slowly -

### Compounds

$HBr$   $\rightarrow$  the greatest analogy with  
 $HCl$  - Produced in the same  
way. By Direct Combination  
of  $H$  +  $Br$ . Second - by treating  
a  $Br$  Compound with a strong  
acid  $H_2SO_4$  }  $NaOSO_3$   $\uparrow$   
 $H_2SO_3$  }  $HBr$   $\uparrow$

Objection set free by the Oxidizing  
Effect of  $SO_3$  - but how  
the acid acts we don't know.

The best way of preparing  $HBr$   
is to heat some  $Br$  Compound in  
 $H_2$  gas  $Pd$   $Br$  }  $HBr$   $\uparrow$   
 $H$  }  $Pt$ .

HBr.  
Properties.

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A colorless gas - like HCl.

Fumes in the air - in that, it takes up H<sub>2</sub>O vapor with avidity.

Sp. grav. 2.74006.

Composition by volume

1 vol H = 0.06927

1 vol Br = 5.41085

2 vol HBr. 5.48012

1 v HBr - 2.74006

✓ 4 Ex

By bringing litmus paper over HBr. gas it is not affected - but turning it end upward - it is reddened.

The same metals that decompose HCl - ~~that~~ decompose also HBr. The acid character of HBr can be destroyed by bases & when the acidity is completely vanished, the resulting substance is a neutral Bromide as with Chlorine Compounds.

Anal  
ogy  
with  
HCl

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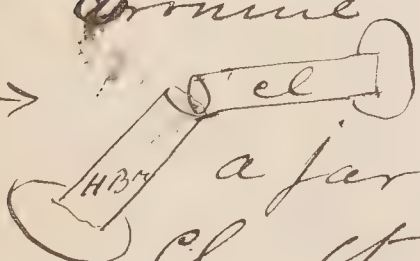
They are 1<sup>st</sup> Direct combinations  
Three of the Elements - :

ways of 2<sup>nd</sup>, Bringing the Body to be  
forming combined into contact with  
a body that gives up Br. readily.

Bromides

3<sup>rd</sup> Treating the body with Hydro-  
Bromic acid.

If we add to HBr. Chlorine - the  
Ex Bromine will be separated

→  If we invert over  
a jar of HBr - a jar of  
Cl - the colorless HBr will  
become dark red from the  
Bromine separated.

In all cases Chlorine will ~~be~~  
displace Bromine - atom for  
atom, & we have through this  
a safe means of analyzing  
all compounds of Bromine -  
By - volumetric analysis with  
a normal Cl. solution.



The ~~nature of the~~ analogy between  
 $\text{HCl} + \text{Br}$  + between all the  
 $\text{Cl} + \text{Br}$  Compds is so great - that  
 not only are the compounds sim- ilar  
 in their physical properties -  
 + their method of manufacture -  
 but they give also the same tests  
 with the general reagents.

(AgNO<sub>3</sub>, PbO, A. BaCl) ← Illus  
 $\text{AgBr}$        $\text{PbBr}$       nothing  
 ↓                      ↓

With these precipitates the dis- How to  
 tinction from the corresponding distin-  
 $\text{Cl}$  compounds is very difficult. guish

$\text{PbBr}$  is somewhat more  
 difficultly soluble than  $\text{PbCl}$ .  
 in  $\text{H}_2\text{O}$ .  $\text{AgBr}$  is not so purely  
white - but with  $\text{NH}_4\text{O} + \text{NO}_3$  gives  
 the same Reaction -

But the real test for the  
 presence of Bromine is as follows -

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 $CS_2$  To the suspected solution add  
+ a few drops of  $CS_2$  - then  
Cl. No. some Chlorine Water - Brom-  
ine will be separated -  
Will be absorbed - (dissolved)  
in  $CS_2$  + sink to the bottom  
This may be continued till all  
the Br is dissolved out from  
the solution - + the amount  
dissolved in the  $CS_2$  quantita-  
tively determined.

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The safest + best method of analyzing Br. Comp'ds. is to bring the substance (in a liquid form) to be tested - in a porcelain dish over the lamp - heat to boiling. Then from a burette (marked to 1/10 C.C.) drop into the boiling fluid, little by little - a solution of Cl. HO, of known strength, (how this is prepared - will be learned hereafter). after each addition boil until the brownish yellow color of Br has disappeared - when no more coloration ensues - the operation is complete + the Ceonine has replaced alone for alone the Br. (we can by a careful analysis - hit the point of replacement exactly - + the result will be an accurate one - Let us call



$c$  = the amount of Cl.

(Cl in 1cc = 0.001 - m.g. (=  $\alpha$ )

Anzahl der c.c. =  $t$

$$\text{Cl} : \text{Pr} = \alpha : b$$

$$\frac{\text{Pr} \times c}{\text{Cl}} = b \quad \text{or} - \alpha t = c$$

$$\frac{\text{Pr} \times \alpha t}{\text{Cl}} = b$$

This is the only safe way of determining the amount quantitatively of Pr. in the presence of Cl.

The Pr separated by the Cl at each drop is kept volatilized by keeping the fluid constantly in boiling when the liquid is no more colored by Cl HO - the Pr has been replaced alone for alone by chlorine. ( $t=30$ )

$$\text{then } \frac{80}{35.5} \times 0.03 = \underline{b}$$

## Oxides of Br.

Although it may be possible to combine Bromine in several proportions with Oxygen - as yet it has been possible only to form One compound of Bromine with the O - namely - One which is analogously constituted with  $\text{ClO}_5$ . The Bromic Acid  $\text{BrO}_5$  - It would seem from

the close analogy of Chlorine & Bromine in all their compounds that here too with Oxygen they should show also corresponding identity in Character - & but it perhaps may hereafter be successfully shown that this identity does exist, though as yet it has not succeeded.

BrO<sub>3</sub>-

Formed just as ClO<sub>3</sub>- - by leading a stream of Br through a strong base to supersaturation - through KO for example. Has the greatest resemblance to ClO<sub>3</sub>- salts. Strong <sup>mixed</sup> Oxidizing agent - explodes with a combustible body with a blow.

Bromates

By heating all O goes off + KBr. is formed.

Decomposed by 2HBr + HCl.

With the reagents -

|                     |         |          |                         |
|---------------------|---------|----------|-------------------------|
| AgNO <sub>3</sub> - | { PbOAc | { BaCl - |                         |
| nothing             |         |          | nothing                 |
|                     |         |          | (BaO BrO <sub>3</sub> ) |

Compds Cl + Br.

If we add to a solution of Br in water, Cl water, a compound of lighter color formed (Clor Brone - a little interest



## Iodine.

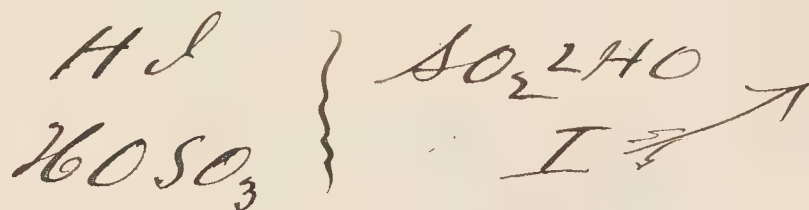
Between this Element + its compounds - the closest analogy exists with the Compound of Cl + Br - just as between the compounds of Cl + Br themselves - of Iodides. Where Cl + Br compound occurs to Br + in Nature occurs also - Iodides Clorides + the method of obtaining their compounds free precisely the same, in Spring Waters - but particularly in Sea Waters - it accompanies Cl + Br compounds. But though universally spread Occurs - it only occurs in small quantities - & just as Bromine occurs Nature with Cl - but always with less quantity - so Iodine occurs in Quantity smaller quantity than either Cl or Br. (One exception is said to be a mineral Spring in Ser Robinson).

Discovered by Courtois in Paris in 1811 in the residues of sea plants.

→ In the plants of the seas - the iodine compounds are held, more concentrated as it is taken up by the roots. + serve for the nourishment of the plants, from these it can be technically made with advantage.

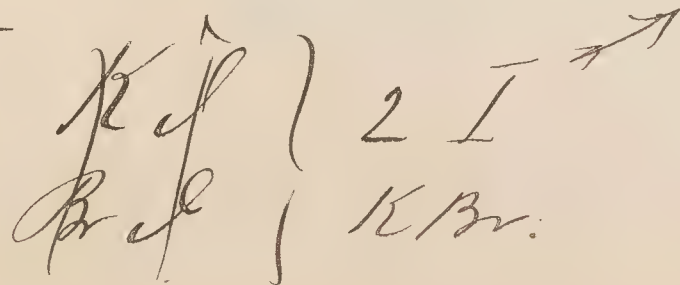
The sea-plants (Fucoiden) are Manuf. burned & the ashes treated active with a mixture of  $MnO_2$  &  $SO_3$  by which Br & Iodine are both set free, & condensed in appropriate condensers. The greatest amount of I in manufac. comes from Glasgow, but it is not by any means Chemically pure.

The purest + best  
 Iodine - is that which is  
 manufactured in Paris - it needs  
 little or no purification for  
 chemical use -  $\text{SO}_3$  will drive out  
 Iodine from its compo's without  $\text{MnO}_2$



This Iodine is  
 distilled + condensed - + is thus  
 obtained tolerably pure. This it  
 is from the first separated from  
 Bromine + needs no purifi-  
 cation. as it otherwise would  
 need from Br, which would  
 be carried out by distilling  
 the mixture with  $\text{KI}$ .

Thus -





## Properties -

At ord. temps - a solid - metallic  
lustre resembling C. most in thin  
leafy plates - lamina. Sometimes  
in Rhombic pyramid. Sp. grav.

4.95. ( $H_2O = 1$ ), a peculiar & un-

pleasant-smell. At ordinary  
temp - it is slightly volatile - a

Exp. Gentle heat is converted into a  
beautiful violet vapor.

Soluble in water - but very slight-  
ly - the higher the temperature  
the more is it soluble in  $H_2O$  -  
(Br & Cl behave the contrary) -

$KI + C_4H_6O_2$  dissolves and  
Iodine -  $C_4H_5$  dissolves also -

$KI$  dissolves the most.

$CS_2$  & Chloroform dissolves  
it out with a beautiful  
violet color. The color of the  
other solutions is brown.

With Starch - a beautiful  
beautiful blue color - Exp

With glazed paper this blue color is likewise produced -

glazing is made with starch.

nearby Reactions

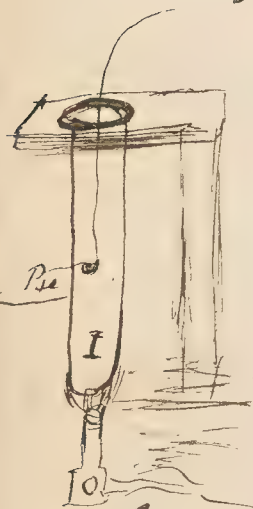
All those observed by Cl + Br -  
are brought about with I

but still with weaker affinity

With H<sub>2</sub> - I will not  
combine - at any temp. Exp

erature -

Phosphorus, combines  
at ordinary temps - but Exp  
with very little flame  
so with As + Sb (upon  
heat)



Li<sub>2</sub> (with foil) can also be  
burned at ordinary temp - Exp  
more vigorously by heating -  
Bras foil ditto

Na, K, & the metals of the first four groups burn in it with a very intense flame -

But just as Bromine shows all the combinations & surprising analogies with Cl - but with all weaker affinities & less energetic chemical action in its combinations - so Iodine shows precisely the same analogy - with both Cl & Br - but with still weaker affinities than either Cl or Br.

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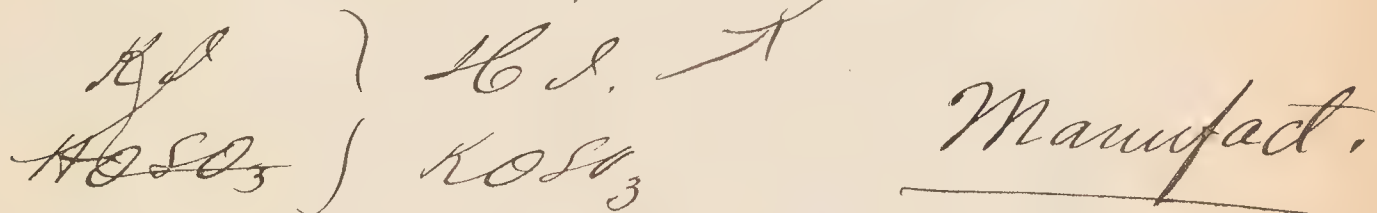
# Lecture 43<sup>rd</sup>

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H.I.

Can be obtained first as  $\text{HCl}$  +  
 $\text{HBr}$  - but is much more -  
decomposable than either.

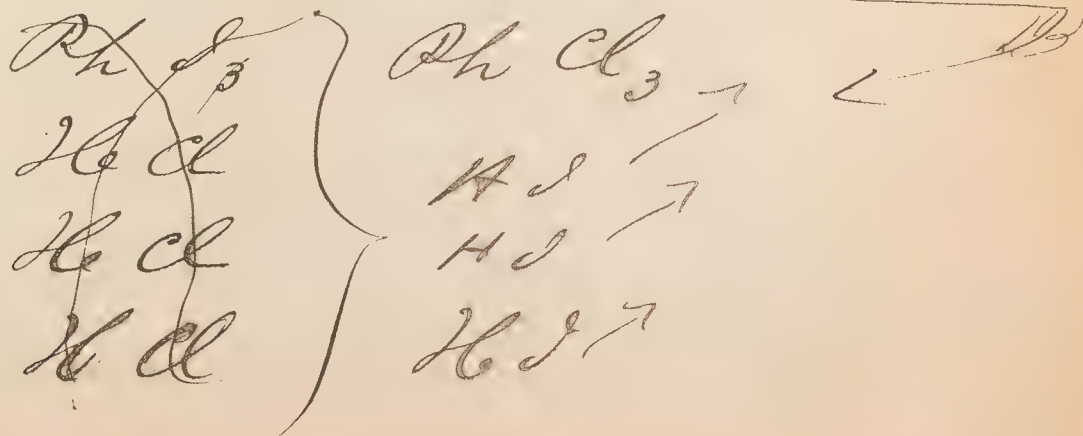
It cannot be produced by direct  
combustion. Namely - by treating  
an Iodide with a strong acid



Thus as always impurified  
with Iodine. To obtain pure  
H.I. more pure. Lead  $\text{HCl}$  -  
over  $\text{Pd}$  &  $\text{Pd}$ .



treating such a compound From  
with  $\text{HCl}$ . thus ———:  $\text{PhI}_3$



# Properties

HD → Equiv. 128. Is a colorless -  
 gas, of a suffocating odor - pass.  
 ing an acid reaction - giving  
 out thick white fumes, in con-  
 tact with moist air. Speas.  
 Grav. = 4.443 (air = 1), In all its  
 relations possessing an exceeding  
 → analogy to HCl + HBr. Can be  
 condensed to a liquid with ease - +  
 Comp. by likewise to a Ice like solid.

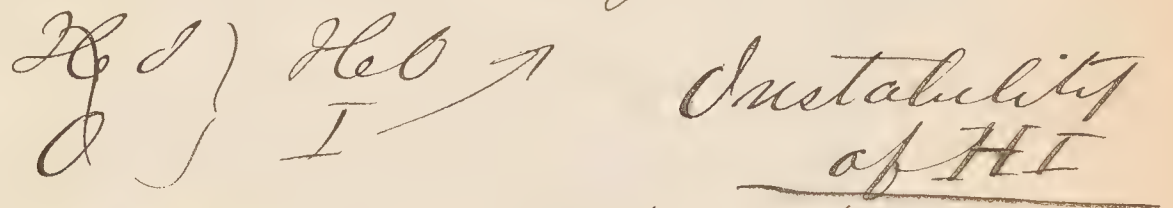
Volume Comp. by vol. like HCl + HBr.

Exp.  $\frac{1}{2}$  vol H<sub>2</sub> = 0.0345 { I have sp. gr. -  
 $\frac{1}{2}$  vol I = 4.3250 { + acidity of  
 1 vol HD = 4.3575 { HD more  
 Exper.

Decomposed at  
 incipient Red Heat - (A  
 red hot glass rod, plunged  
 into HD gas - decomposes  
HD into H + D - + as they  
 don't combine directly they rem. sep.

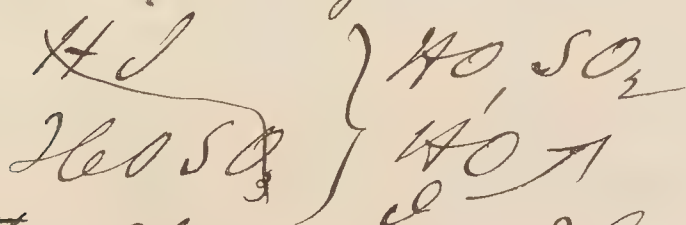
Exp

The  $\text{H}$  of  $\text{H}_2\text{S}$  is more easily oxidized than either  $\text{HCl}$  or  $\text{HBr}$  - at ordinary temperatures - in contact with moist air -  $\text{H}_2\text{S}$  is decomposed.



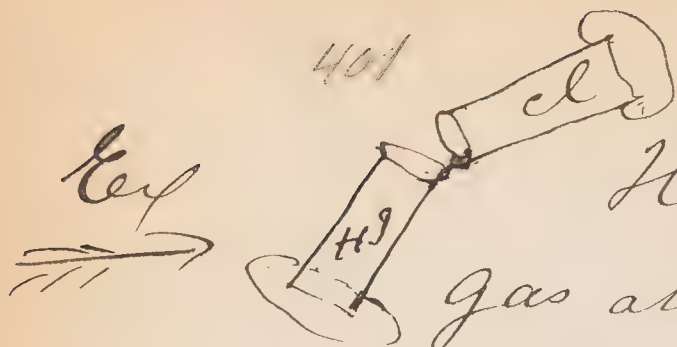
Brought into Contact with a strong oxidizing agent - it is decomposed violently & with the Phenomenon of Combustion - with  $\text{NO}_2$  for Ex example

With even  $\text{SO}_3$  -  $\text{H}_2\text{S}$  is oxidized -

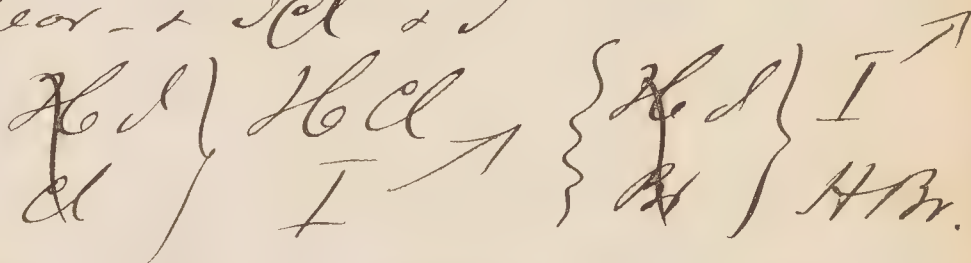


With Chlorine  $\text{HCl}$  is formed &  $\text{S}$  is set free. If excess of  $\text{Cl}$  is present compounds of  $\text{S} + \text{Cl}$  are formed  $\rightarrow$





Heats a vessel of  $\text{Cl}$  gas above one of  $\text{H}_2$  - slightly inclined at first - & the  $\text{I}$  vapors will be seen; incline more & these disappear - &  $\text{HCl}$  &  $\text{I}$



With Bromine the same decompositions are Brought about as with  $\text{Cl}$ .

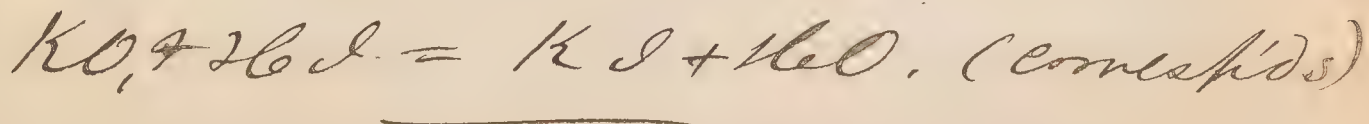
Exp

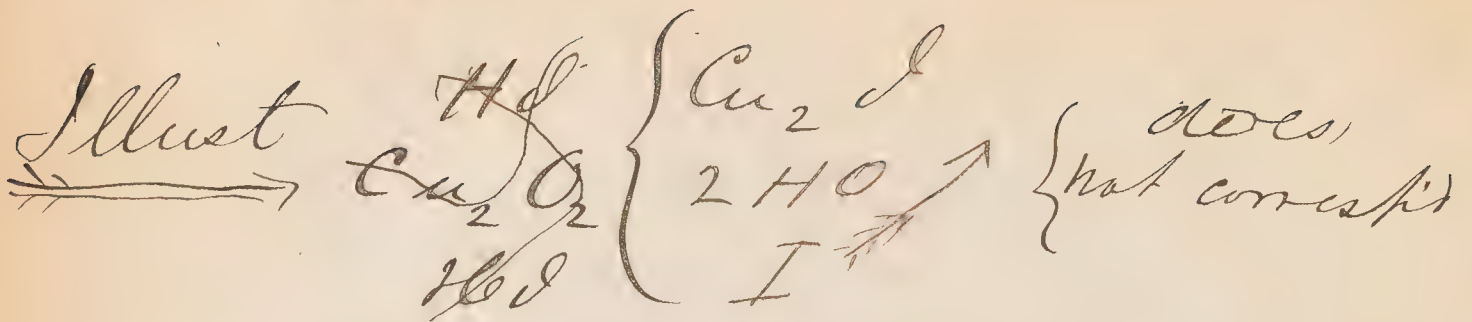
These experiments give us an insight into the relative affinities of these bodies, they are to be placed - in the following order of strength -  $\text{O}, \text{HCl}, \text{Br}, \text{I}$  - or perhaps better  $(\text{Cl}, \text{O}, \text{Br}, \text{I})$  The Hydrogen compounds of each succeeding Element - will be decomposed by the presence of each preceding one.

in  $\text{H}_2\text{O}$ ,  $\text{HI}$  is very soluble,  
more so than  $\text{HCl}$ .

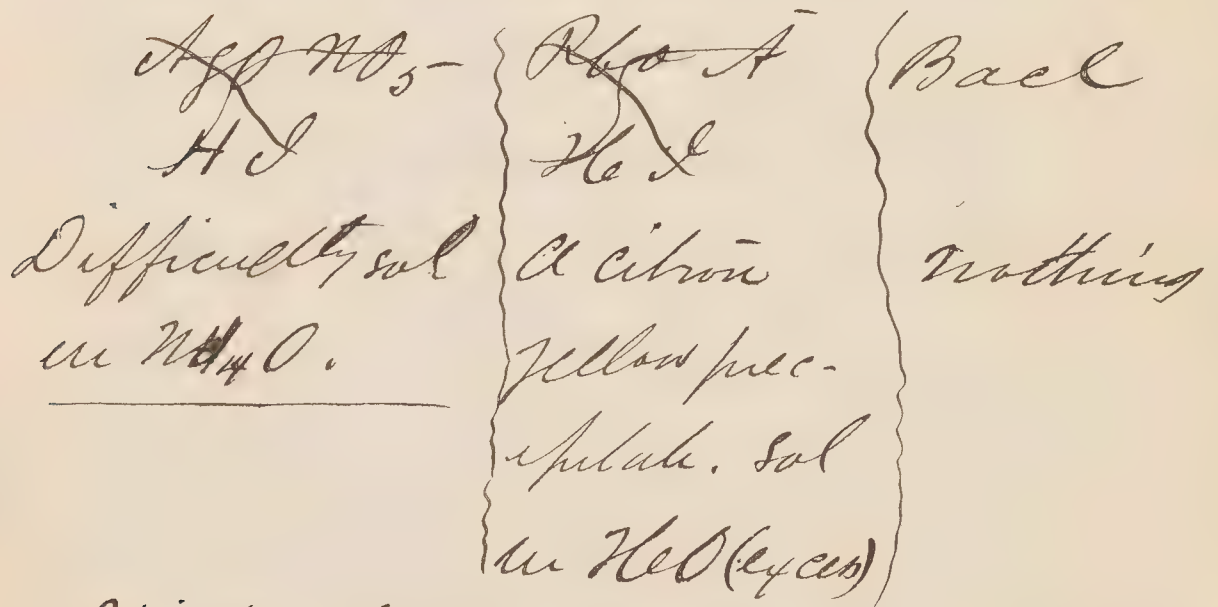
At  $127^\circ$  it has a constant  
Boiling point; but no compd  
is formed - for by changing  
pressure we change not only  
the Boiling point - but also  
the per cent of  $\text{HI}$  in solution -

The reactions of  $\text{HI}$  & the  
Compounds of  $\text{HI}$  - are very Beha  
similar to  $\text{HBr}$  &  $\text{HCl}$ . The vor of  
 $\text{HI}$  - neutralizes strong Iodides  
Bases, & at perfect neutral-  
ization the neutral Iodide  
is formed, this is the best  
method of forming Iodides -  
But the corresponding Iodide  
to an Oxide is not always -  
formed as with  $\text{HCl}$  or  $\text{HBr}$ .





### Reactions



Special Tests  $\rightarrow$  With H<sub>2</sub>GO-salts we get a red precipitate of H<sub>2</sub>GO - (easily soluble in H<sub>2</sub>O).

Ex These precip. H<sub>2</sub> are the property of forming double Iodides (H<sub>2</sub>GO, KI) - These reactions are not sufficient to distinguish the Iodides per se - for. these precip. may all be mistaken for others - similar to them.



There is one method, which gives us a sure reaction for Iodine compds - namely - Iodide

By adding to a solution of Starch containing an iodide - Starch (in solution in  $H_2O$ ), & then - bringing,  $Cl$ , or  $Br$ , or, an acid & an Oxidizing agent, - into contact with it - the Iodide is decomposed & Iodine set free; which combines with Starch - gives a blue precipitate starch determine.  
If we let  $Cl$  act upon  $KI$  - Determine.  
( $Cl + KI = KCl + I$ ) if we add too

much - we obtain a brown compd of  $Cl$  &  $I$ . ( $KI + 5 Cl = KCl + ICl_5$ )  
All the intermediate compounds of  $Cl$  &  $I$  - have the property of dissolving up in  $CS_2$  with violet color. Only the  $ICl_5$  does not - dissolve in  $CS_2$  with this color - for

$I\text{Cl}_5$  is colorless. when therefore 5 atoms of  $\text{Cl}$  has been brought into the fluid; it must appear colorless - & we have a simple proportion -

$$\text{Cl}_6 : I :: x t : y.$$

Exp

$$\frac{I}{\text{Cl}_6} x t = y$$

The standard solution of  $\text{Cl HO}$  is prepared by a previous volumetric analysis, with a standard solution of  $I$  in  $\text{K I}$  & of a weak solution of  $\text{K O}_2$  - It must be kept closely stoppered, & before each analysis should be again tested to determine its quantitative value for the C. C. In using the mouth of the Burette should be filled with Cotton.

## Compds with O.

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$\text{IO}$  anhydrous  
 $\text{IO}_4$  "  
 $\text{IO}_5$  "  
 $\text{IO}_7 + \text{HO}$  not "

The most important is  $\text{IO}_5$ , the others are of small importance.

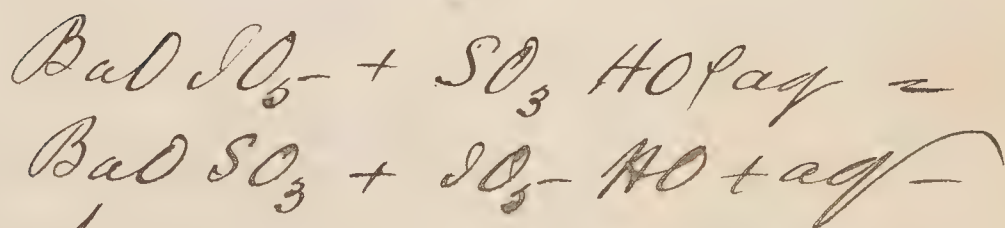
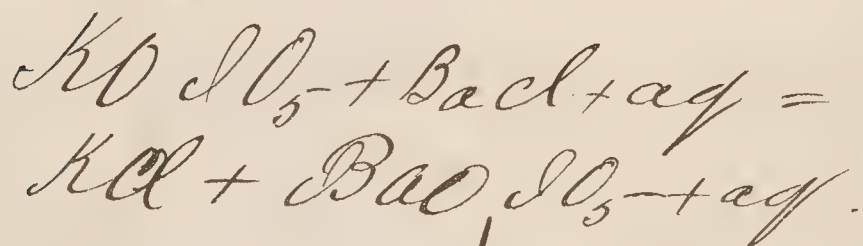
It is prepared in a manner analogous to that by which the acid  $\text{ClO}_5$  was prepared.

namely - by converting Sodate of Potassa ( $\text{KO IO}_5$ ) which is a soluble salt into, Sodate of Baryta ( $\text{BaO IO}_5$ ) - & Manuf. treating this insoluble compound with  $\text{SO}_3$  - Insoluble  $\text{BaOSO}_3$  is formed & which falls out. &  $\text{IO}_5$  is set free & can



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be concentrated to a  
convenient point. The excess  
of  $\text{SO}_3$  if added, should be  
carefully removed by  $\text{BaCl}_2$ .  
(or  $\text{BaONO}_2$ ).

Reaction is as follows.



## Lecture 44<sup>th</sup>

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### Compds of Iodine + Oxygen

$\text{IO}_-$  is of small importance - is very decomposable - & forms no salts.

$\text{IO}_3^-$  is formed also by simple oxidation of  $\text{I}_2$  suspended in  $\text{H}_2\text{O}$ . With  $\text{Cl}_2$ .

$\text{IO}_3^-$  by

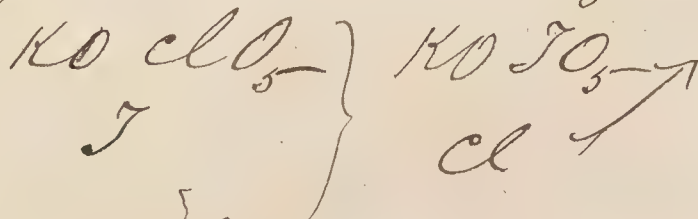


Oxida

not however practical.

tion

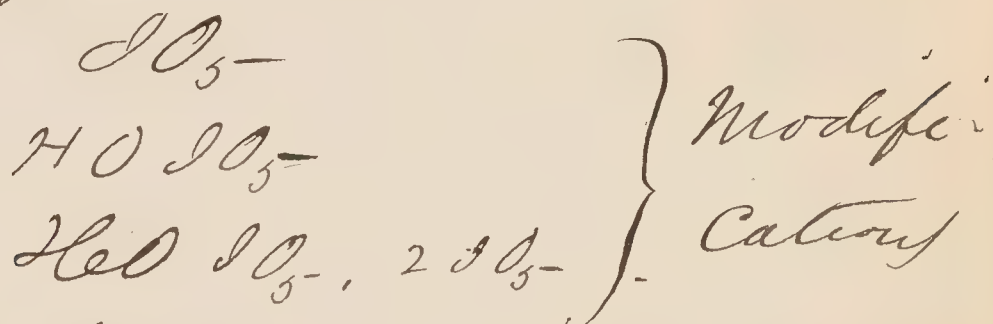
With  $\text{NO}_3^-$  it is easily oxidized & of practical use. we prepare it generally thus. Or again



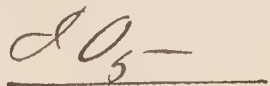
(small quant.)  $\text{NO}_3^-$

Is a good way to form Potash Salt of  $\text{IO}_3^-$  - This salt can be converted to  $\text{BaIO}_3$  & the  $\text{IO}_3^-$  separated.

ted by  $\text{SO}_3$  as given before.  
The acid occurs in three  
modifications -



The first is soluble in  $\text{C}_2\text{H}_5\text{O}_2$



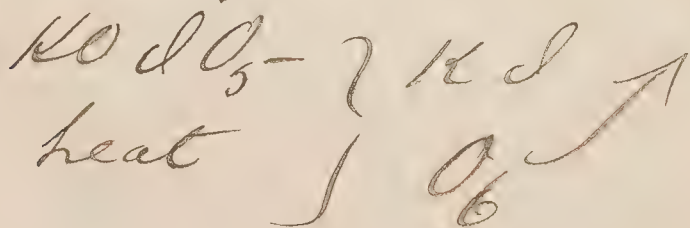
A white powder. by heating  
is decomposed into  $\text{S} + \text{O}_6-$

We can thus easily analyze  
the acid by simply measuring  
the  $\text{O}-$  (Show  $\text{O}-$  given off)

Exp

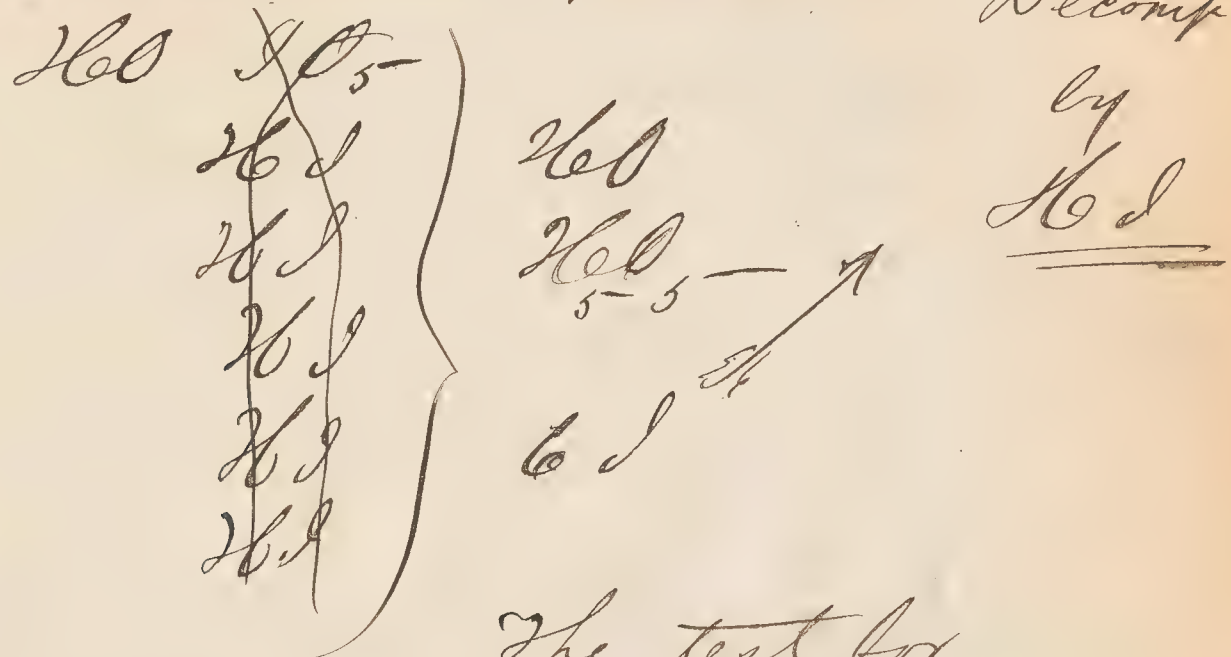
$\text{S}$  is soluble in  $\text{H}_2\text{O}$ . which can  
be replaced by Bases.

On heating the  $\text{SO}_3-$  salts they  
behave just like the Chlorates





With  $\text{HCl}$  a complete decomposition takes place -



The test for the Iodates is the following - a similar procedure <sup>as</sup> with  $\text{ClO}_3^-$ .

The substance is heated - Tests

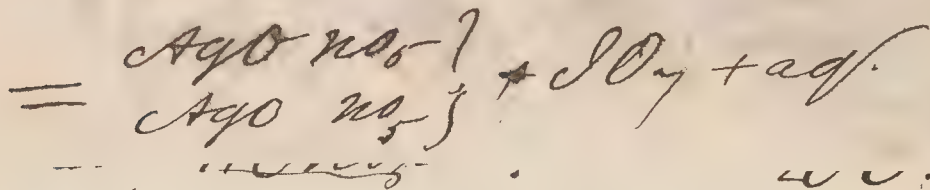
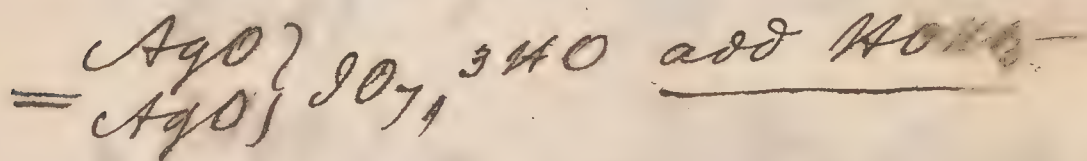
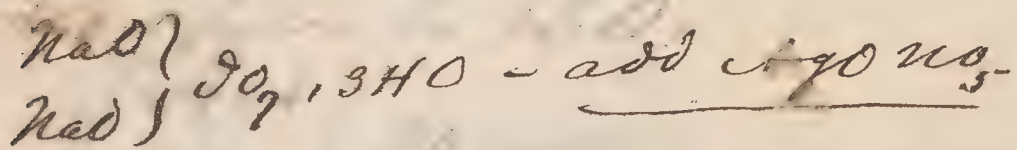
until all the  $\text{O}_2$  is given off.



The Iodide remaining behind is then determined, by a titration with Chlorine Water +  $\text{CS}_2 \rightarrow$  out of the amount of Iodine found the value of the  $\text{IO}_5^-$  present can be determined.

# SO<sub>2</sub> HO.

It can be manufactured in combination with a base, by slightly heating, (Mol SO<sub>2</sub>-pr. exp.)  
 Manufac. whereby, part of the salt will  
 turn be oxidized to 2NaO SO<sub>2</sub> at the expense of the rest of it. This can be converted into 2AgO SO<sub>2</sub> 3H<sub>2</sub>O + the



It is soluble in H<sub>2</sub>O + in C<sub>4</sub>H<sub>6</sub>O<sub>2</sub> - & is therefore, Deliquescent. Acts powerfully Oxidizing upon Organic bodies - explodes in their presence. So decomposable by H<sub>2</sub>S. H<sub>2</sub>Cl, & SO<sub>3</sub>.

can be analyzed just as the  $\text{IO}_5$  & is somewhat, more decomposable.

$\text{IO}_4$

Precisely analogous to  $\text{ClO}_4$   
A sure method of preparing this substance has not yet been devised - the name of acid applied to it, is a Manufacturing. A solid, body at times Ord. Temp's, readily decomposed by heating or by Hot  $\text{H}_2\text{O}$ .

Is perfectly neutral - neither acid nor base. Properties -  
Insoluble in  $\text{H}_2\text{O}$  - Water difficultly decomposes it.

The name is not well applied - by which this substance is generally called - viz - Hypoiodic acid - as it possesses neither acid nor basic properties.



I & Cl

$I\text{Cl}$   
 $I\text{Cl}_3$   
 $I\text{Cl}_5$

} Interesting but un-  
important Comp'd's -

Manufacture → I & Cl together - directly - with  
 somewhat excess of I. A dark  
 red fluid - which has the prop-  
 erty of becoming solid - even  
 though kept in hermetical-  
 ly sealed glasses - Why?  
 We are unable to say.

$I\text{Cl}_3$  formed from I & Cl -  
 by continuing to lead Cl -  
 upon I & Cl 'till the yellow  
 crystals of  $I\text{Cl}_3$  - appear in  
 a concentrated solution?

$I\text{Cl}_5$  - by allowing a contin-  
 uous stream of Cl - to play  
 upon the preceding Comp'd.

$I\text{Cl}_3$ 

We have no positive evidence of the existence of this Comp'd. but, if we lead  $\text{Cl}$  upon a solution of  $\text{I}$  in  $\text{CS}_2$  - until it becomes colorless - there is just 1 atom of  $\text{I}$  + 5 atoms of  $\text{Cl}$  present, & from the constancy of this phenomenon we judge, a comp'd is formed.

Fluorine

Would have

much more analogy to  $\text{O}_2$  - than to  $\text{Cl}$  or  $\text{Br}$

We have as yet, no positive evidence that  $\text{Fl}$  has been isolated - so that we cannot judge of its physical properties. We can therefore judge of its chemical properties by the compounds which it forms.  $\text{Fl}$

Attempts to isolate  $\text{Fl}$ , have not yet succeeded

In ~~the~~ nature it is widely spread, & particularly in the mineral Ca Fl. or in Ceresolite

Compds (Ca Fl. Al Fl<sub>3</sub>?)

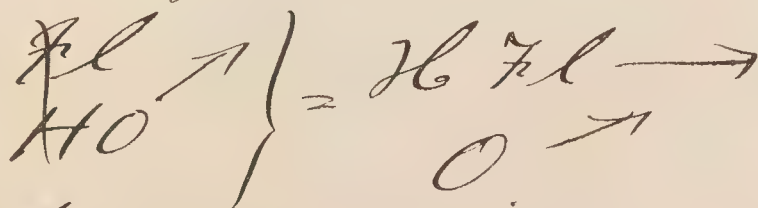
Attempts  
to  
Isolate  
Fl

The methods by which it was attempted to isolate Fl. were similar to those which were ~~at first~~ used to separate O. or Cl & C. First by simple glowing - the Compds of Gold Pt. Pd & C. - we know have the property of giving up their nonmetallic ingredient by simple Heating - & of leaving metallic gold (or Pd & C) behind - but these elements singularly enough, do not form Compounds with Fl. - for all attempts to combine them directly or indirectly, have failed.



With a higher Oxide + H<sub>2</sub>O  
 the result is no better - for  
 compounds of the metals which  
 form Super oxides; + with  
 H<sub>2</sub>O, are unknown - & no ac-  
 tion is the result.

It is doubtless possible that  
 by decomposing - a solu-  
 tion of H<sub>2</sub>O by the Gal- By Elec.  
 vanic Battery - that H<sub>2</sub>O is trical  
 separated at the positive Decomp.  
 pole; but at the instant of  
 its separation, H<sub>2</sub>O is again  
 formed by the separated H<sub>2</sub>O -  
 decomposing the water. -



So that Oxygen instead of H<sub>2</sub>O  
 is obtained at the positive pole.

417 Compds of Fl.  
HCl

Fluoride Plays an important part in nature - they are very widely spread - are necessary for the nourishment of Plants & animals, & form an important article for the manuring of Cereals.

By treating Ca Fl with a strong acid



But a difficulty appears in collecting it its affinity is so strong - that Difficult unlike all other gases it attacks glass (the  $\text{SiO}_2$ ) - ~~hence~~ <sup>not</sup> only collects  $\text{SiO}_2$  but also most metals except Pb or Pt; so that it cannot like ordinary acids or bases - be kept, or even caught in glass vessels -

or even be manufactured  
 in them - It must therefore  
 be manufactured in Platinum  
 retorts (for Pb. is not alto-  
 gether unattacked by this acid),  
 & must be caught in a ~~thin~~  
~~telluric~~ vessel of Platinum  
 or Gutta-percha. The gas  
 when pure - is a colorless-  
 gas, forming out thick white  
 clouds in moist air - & pos-  
 sessed a fearfully irritating  
 odor - which is not the only  
 disadvantage to him manu-  
 facturing it - for the fumes  
 are positively poisonous, &  
 breathed (concentrated) produce  
 death; - of the acid solution in  
 H<sub>2</sub>O. which absorbs it with  
 avidity - a drop upon the  
 skin produces - a disagreeably



dangerous ulcer - which  
obstinately refuses to Heal, as  
Gay Lussac - who first man-  
ufactured this gas. found  
to his sorrow.

The gas is easily condensed -  
to a liquid - by tolerable cold,  
+ forms a thin colorless fluid  
resembling  $C_4H_6O_2$  - So dan-

gerous are the fumes - that  
the manufacture must al-  
ways be attended with utmost  
Caution - , + ordinarily lead  
the gas should be lead into  
a vessel <sup>with</sup> of  $H_2O$ , to condense  
all the fumes. (Note - the  
neck of the retort should only  
partially dip into  $H_2O$  - other-  
wise - the pressure of  $H_2O$ , on the  
gas - is so strong that  $H_2H$  may  
escape at the joints of apparatus.

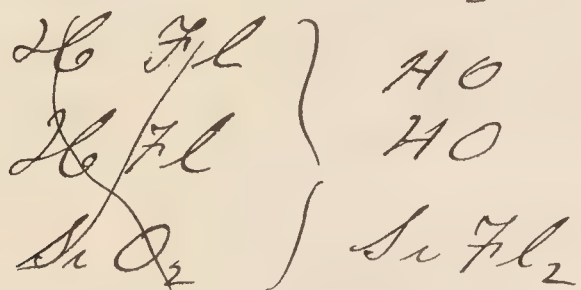
Proper -  
test



## Lecture 45<sup>th</sup> 420

### Uses of Hydrofluoric Acid.

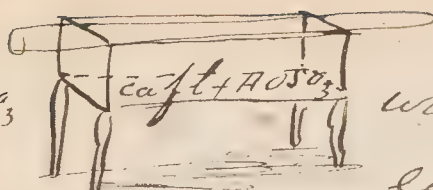
H<sub>2</sub>Fl. is one of all the H<sub>2</sub> acids - decomposable by Metals. Fluorides - & H is set free. One property of H<sub>2</sub>Fl. gives us a sure test for it - the property of combining with SiO<sub>2</sub> with H<sub>2</sub>O.



Of this property we make the most important use - namely to etch glass -

The method is the following - the glass to be etched - is first covered entirely with a thin film of wax - & now, the letters, numbers &c - to be etched upon it are marked finely upon the it, the gas is generated -

Etching  
of  
Glass


 in a leaden trough - with  $\text{Cafl} + \text{HOSO}_3$  in excess - the flap is - then placed above the fumes a sheet of paper spread over the trough to concentrate the fumes & the flap exposed - several hours (or days as the case may be) to the action of the gas - Only those parts which are to be etched - are freed from the wax covering.

With the general reagents  $\text{H}_2\text{F}$  gives precipitates which are soluble with much more ease than  $\text{HCl}$ ,  $\text{HI}$  or  $\text{HBr}$ . But these are not bezel needs, & we in general - fall back upon this one peculiar property - of  $\text{Hfl}$  to etch glass as the <sup>active</sup> characteristic reaction.



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The Etching by Gaseous  $H_2$  is much more distinct than with liquid  $H_2$  - the latter, are too smooth. With the gas the etching is best when no heat is applied, & the gas left gradually to disengage itself. By heating the etching is always irregular - stronger in some places than in others.

The adaptation of this etching of glass by  $H_2$  to Engraving is exquisite; & it has unfortunately not been enough adapted in practice - the finest lines - indistinguishable but with a magnifier can be brought out - the only disadvantage is that glass plates - instead of steel ones - must be used -

Engraving by  
 $H_2$ .

+ these are easily broken -  
 We dare not here, press the  
 plates (as with steel) upon the  
 paper - but must lay the  
 plate upon a perfectly -  
 smooth surface - + then  
 press upon it, the paper  
 to ~~be~~ receive the impression  
 The compounds of Pl with O -  
 Cl. Br. I, etc are not known.

|            |   |           |
|------------|---|-----------|
| Next group | { | Sulphur   |
|            |   | Selenium  |
|            |   | Tellurium |

## Sulphur →

Is the chief representative  
workman of this group of elements  
 It is very widely spread in  
 Nature - + exceedingly abun-  
 dant - It is especially at  
 home in volcanic regions

where it is formed by the <sup>424</sup> volcanic action - as will be seen hereafter -

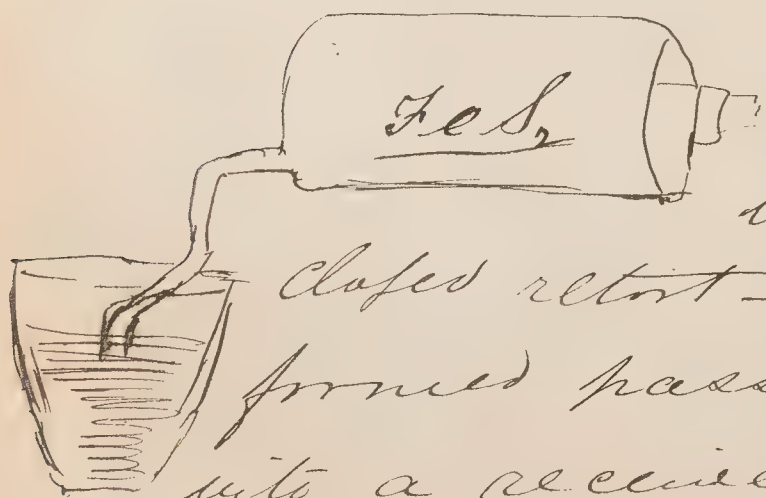
These ~~metals~~ elements give combustions in a gaseous state like Cl, Br, I. They give <sup>an</sup> acids with H<sub>2</sub> like H<sub>2</sub>S chem. - they form compounds with O. (Sulphur for ex.)  $SO_3 + SO_2$  S + O Like Cl, Br &c, this group of elements, the greatest analogy anal- exists between the chemical ogy character of the compounds of these elements. The most frequent compound of S in nature is  $CaO SO_3$  - & forms whole mountain masses; particularly in tertiary formations; again - many Sulphides  $FeS_2$   $PbS$   $CuS$   $FeS$  - &c &c. (H<sub>2</sub>S). By heating  $FeS$  in a closed tube  $Fe_2S_3 + S$  is



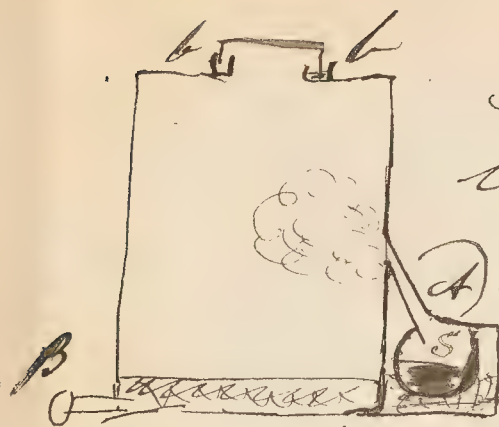
This is the process of its manufacture in active volcanoes. where it is constantly formed in immense quantities. Again - By the decomposition of  $\text{H}_2\text{S}$  gas; either by decomp. in air per se - or by  $\text{SO}_2$  fumes



Do in Gyphs  
 In Gyphs it comes in great masses. The masses of gyphs are - heaped together - & heated the sulphur - is smelted & runs out from the mass.



The  $\text{CaO.SO}_3$  or  $\text{FeS}_2$  is heated in such a - closed retort - & the Sulphur formed passes by the tube into a receiver & is condensed in  $\text{H}_2\text{O}$ . or is run into moulds.



This S is generally  
 impure - it is pu-  
 rified - by redis-  
 tillation - It is Purified -  
 for this purpose brought down  
 into a retort (A) - connecting  
 with a large chamber - (to guard  
 against Explosions - from a combin-  
 ation of S fumes with O - the roof is fur-  
 nished with a loose piece fitting  
 into two grooves filled with H<sub>2</sub>O as  
 at b + b - the consequence of an  
 Explos. will be to blow off this piece  
 & not to burst the vessel. If S flowers  
 are wanted - the distillation is car-  
 ried on slowly - the A fumes then  
 condense in powder form - If  
 Vol S. is wanted it is distilled  
 rapidly - liquid S collects on the  
 floor - is drawn off at B - & run  
 into Moulds.

## Properties

at ord. temp. - a solid. of a  
 → yellow color. exceedingly brittle -  
 becomes negative Electrical by  
 friction. without taste or odor -  
 insol. in H<sub>2</sub>O. Sp. gr = 2.0454 Gys.  
 Vapor = 2.200. Equiv = 16.

Takes on two crystal forms  
 Rhombic + Monoclinic, Vapor  
 possesses a peculiar smell  
 resembling that of Camphor -  
 By heating Sulphur - a  
 remarkable behavior evin-

By ces itself - entirely exceptional -  
 If we heat to  $112^{\circ}$  - it begins to

Allobof. smelt - it forms a light  
 as con - yellow liquid - of only consist-  
 ditions tency - doesn't much mois-  
of S ten the glass walls. If we  
 continue now to heat this  
 fluid. its color becomes con-



timally more & more dark -  
 & then is converted into a gelat-  
 inous condition - by cooling  
 again - it becomes lighter & lighter  
 & finally becomes a gain liquid.  
 If we heat this gelatinous S.  
 it becomes again liquid,  
 & a liquid very dark - & is Ditto  
 by heating this dark liquid  
 it is converted into S vapor -  
 The color of the vapors - are  
 somewhat of the color of Br-  
 vapor - We see then that  
 S exists in two allotropic  
 conditions - If we heat the  
 ordinary S till it melts  
 & forms the yellow fluid -  
 & then pour this liquid into  
 cold water we obtain ord-  
 inary Sulphur. (yellow & brittle)

Lecture 46<sup>th</sup>

By suddenly cooling - at these two points of difference in the liquid condition; we can hold these two conditions fast -

The first (yellow) liquid phase is in cold H<sub>2</sub>O - ordinary S -

Allotrop.  
of Sulphur

the second (dark) liquid phase is a solid totally different -

in its physical properties - dark

colored - + highly elastic (ord

S is light colored + very brittle)

which however has the tendency to go over into ordinary Sulphur

This peculiarity repeats itself -

again by Sulphur vapor. at

this temp. at which S. vapor -

is first formed it has a

sp. grav. of 6. + but by heat-

ing - still further - 800° C.

we obtain a gas of a sp. gr.

of 2. + a difference of three

times its sp. gr. - in the second

Exp

Modification. This great dif. 4/30  
presence may perhaps be exp- 2 Mod.  
lained by sup. the gas at first  
to vary consid. from Gay Lussac's <sup>specimens</sup>  
law of Expansion. being near its of 1 gas?  
condensation point - but it is more  
probable, that here too - an allo-  
tropic Sulphur gas exists?

In the solid form we can dis-  
tinguish several other peculiar-  
ities, without this allotropicity  
namely - in the Crystal form. <sup>Demon-</sup>  
S. crystallizes in two Crystal Phys  
Systems - Rhombic + Mono-  
clinic - the first occurs  
in crystallizing S from its  
solutions (in  $CS_2$  &c) or generally  
when this ensues ~~by~~ at low  
temperatures - & as the form  
that occurs in Nature -  
Monoclinic crystals are formed  
when the crys. ensues from fu- ture  
sion & rapid cooling - (they have  
a tendency to return to Rhombic forms



S. can be dissolved in  
 Solubil. many solvents -  $\text{CS}_2$  -  $\text{C}_4\text{H}_6\text{O}_2$   
 shj. Fatty oils -  $\text{C}_4\text{H}_8\text{O}$  &c &c -

but the best solvent is

Ex.

$\text{CS}_2$  - But it is only the  
 ordinary variety of S -  
 that is dissolved in it - the  
 Elastic S - is undissolved -  
 in it. (a so volatile liquid that  
 crystallization is a Kleinigkeit)

comb.  
 with  
 H<sub>2</sub>

S. supports the  
 combustion like O, Cl, Br &c.

S. cannot at ordinary  
 temperatures unite directly

Ex. with H<sub>2</sub> - at high temper-  
 atures - the combustion may  
 take place - but the compound  
 formed is so decomposable  
 that it falls apart into  
 H<sub>2</sub> + S - so that no direct  
 union of H + S can be brought  
 about.

Just as sulphur burned in Cu  
Oxygen - we can, vice versa, S + O  
burn O in S vapor, with  
a slight flame.

Cl. Br. S burn in S vapor -  
with small flame -

Cu leaf - brought into the  
vapor - inflames itself without  
heating - so with Pb.

Fe burns with a brilliant  
flame, must be slightly heated  
The form sulphides - generally  
in this way - namely - by bring-  
ing together - the substance - To form  
(Generally metallic) + sulphur - Sulphid  
both in a fine condition &  
applying heat - the combin-  
ation then commences &  
the heat from the Chem. action  
supplies the temperature ne-  
cessary, for further combination

Comp's of H+S

Sulphid of Hydrogen =  $HS$

Bi. " " " =  $HS_2$ ?

The latter compound has not been sufficiently studied so that it is doubtful whether its formula is the correct one.

 $HS$ 

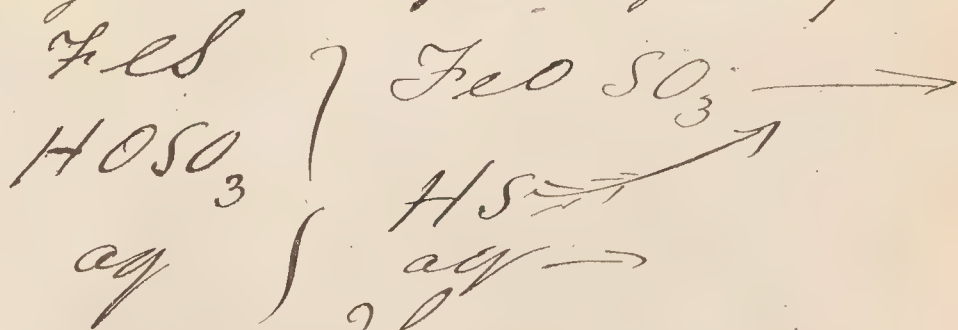
Is widely spread in Nature - formed abundantly in volcanoes. (Just as we do in the laboratory), & from ~~therefore~~ the falling apart of its constituents.  $S$  mesur is so richly formed in these regions. Nature Is abundant in many mineral waters - (formed there from the decomposition of metallic sulphides?) (Particularly in England & in Baden). These waters are then largely visited by invalids for their contents - though ~~poisonous~~ it is poisonous.



By organic decompositions  
 $H_2S$  is formed. Eggs - (the well  
 known odor of venerable ones  
 is  $H_2S$ ).

We form  $H_2S$  in the labor-  
 atory just as we form all  
 Hydrogen acids ( $HCl$  etc,  
 namely - we choose a Sulphide  
 & allow a strong acid to act  
 upon it - in the presence of  
 $H_2O$ ,  $FeS$  is generally used  
 for it is best adapted to  
 disengage the gas gently.

Man-  
 ufac-  
 -  
Laboratory



The gas is ab-  
 sorbed by water & cannot be  
 collected, unless the disengagement  
 of gas - proceeds more rapid-  
 ly than the absorption.

In this manufacture we dare not use an oxidizing agent ( $\text{NO}_2$ ) - for  $\text{H}_2\text{S}$  is still more decomposable than  $\text{H}_2\text{I}$  or  $\text{H}_2\text{Br}$  - instead decomposition would result.  $\text{H}_2\text{S}$  burns

Combustion with a bluish flame to  $\text{SO}_2$  &  $\text{H}_2\text{O}$  - in this decompos.

Ex some S. is set free & sublimed. By electricity it is decomposed into  $\text{H}_2$  & S.

### Properties

$\text{H}_2\text{S}$  is a perfectly colorless gas.

Properties possessing a disagreeable odor (that of rotten eggs) - & of a disagreeable taste. It is irrespirable - acting as a positive poison. It is convertible to a liquid under pressure - is combustible burning with a blue flame to  $\text{H}_2\text{O}$  &  $\text{SO}_2$ .

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By electrical decomposition  $\text{H}_2\text{S}$  the volume of the trypsis gas is not altered. hence of  $\text{H}_2\text{S}$  the composition is by vol. Ex

$$773^{\text{cc}} \text{H}_2\text{S} = 1.1726$$

$$773^{\text{cc}} \text{H}_2 = 0.0698$$

$$\text{Sum H}_2\text{S} = 1.1053$$

$$\text{Sp gr of S} = 2.2112$$

$\text{H}_2\text{S}$  is composed by volume of  
1 vol H +  $\frac{1}{2}$  vol S.

or

$$\begin{cases} 2 \text{ vol H}_2 = 0.139 \\ 1 \text{ vol S} = \frac{2.211}{2} \\ 2 \text{ vol H}_2\text{S} = 2.350 \\ 1 \text{ vol H}_2\text{S} = 1.1726. \end{cases}$$



$\text{H}_2\text{S}$

may be decomposed by  
simple heating or few de-  
grees. Can be condensed  
by Pressure to a colorless  
liquid - a pressure of thirty  
atmospheres is required.



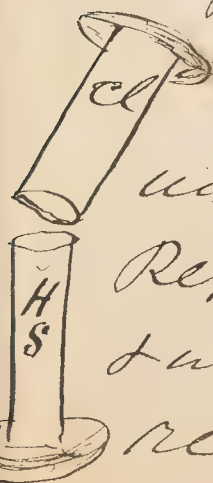
Mode of Condensing by putting  $\text{H}_2\text{S}_2$   
 in an hermetically sealed  
Condensing tube, by slight heating (or  
 Ex  $\rightarrow$  per se?) it is decomposed  
 into  $\text{H}_2\text{S} + \text{S}$ . When the end  
 of the tube is broken an ex-  
 plosion ensues. Why? It might  
 be supposed that the liquid  
 being under less pressure would  
Ex not explode - But this en-  
 surer on the general prin-  
 ciple that, this liquid exists  
 only under great pressure -  
explosion & when this is removed - the  
 liquid suddenly assumes a  
 gaseous form, & the shock  
 of this sudden transformation  
 gives us the explosion.

$\text{H}_2\text{S}$  is pois-  
 onous - but its effects have  
 in this relation have been ex-  
 aggerated.

Upon burning.  $H_2S$  at Combustion  
 first the  $H_2$  burns ~~fast~~ - slow  
 & ~~separates~~ separates. the Combustion  
 of the Sulphur is never Expt  
 complete, but, some of it al-  
 ways separates in the form  
 of a white powder.

It is more decomposable than  
 $HCl$ ,  $HBr$ , or  $HI$  - that is, its  
 Hydrogen is held much more  
 loosely, & is oxidized more eas-  
 ily - than ~~with~~ either of the  
 above mentioned gases - Decom-  
 as the following Experiments possibility  
 will prove. of  $H_2S$   
compared  
with  
 $HBr$  +  $H_2$

Bring a jar of  $Cl$  upon



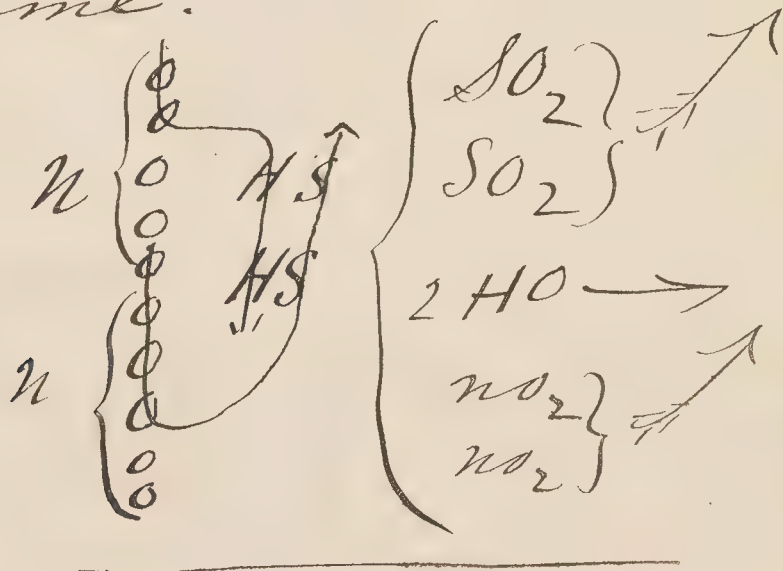
one of  $H_2S$  - the follow-  
 ing occurs  $H_2S + Cl = HCl + S$

Repeat the same with  $Br$   
 & with  $I$  - the same general  
 reaction follows.

Eq -

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Decomp. Brought into contact  
 action with a powerful oxidizing  
by  $\text{NO}_3$  agent - (with fuming  $\text{NO}_3$ ,  
Ex for example) the gas inflames  
 itself spontaneously &  
 burns with an intense  
 flame.

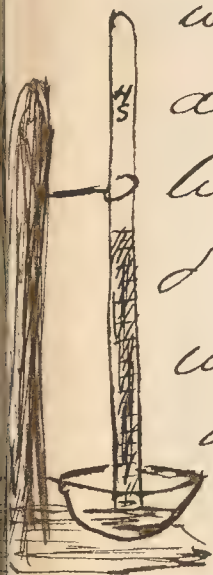




# HS Lecture 47<sup>th</sup>

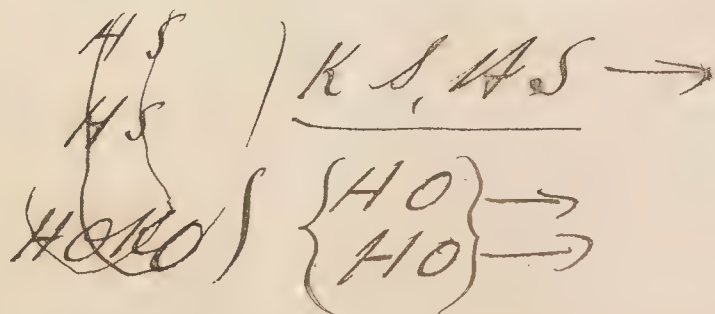
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The gas as remarked Absorption  
in last lecture is some- by  $H_2O$ -  
what, though not greatly- Exp  
absorbable in water - a  
tube filled with the gas- Use after  
& shaken with a few little Sol. in the  
water - if placed over a fluid- Laboratory  
will be slowly filled with Water.

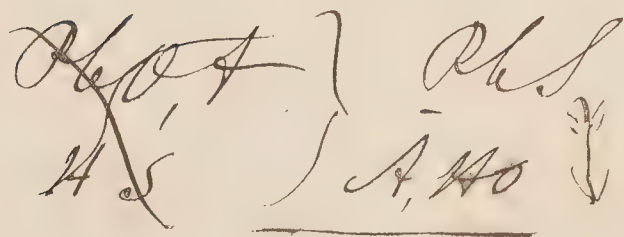
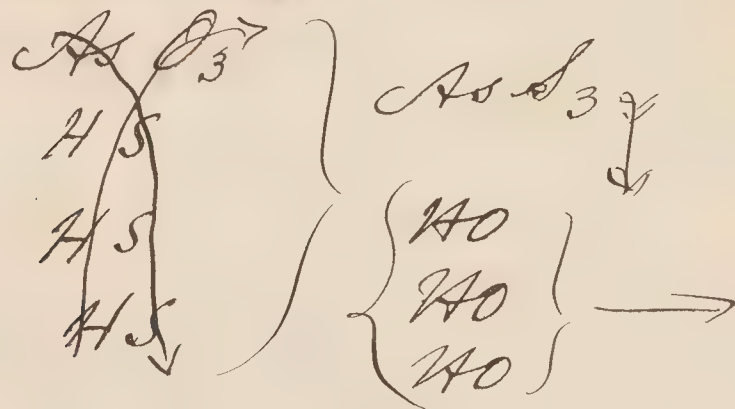


It is a weakly  
acid substance, It is easily ab-  
sorbed by a solution of a strong Exp.  
base ( NaOH than by Water ).

$NaOH \cdot HS = NaS + H_2O$ ,  $NaS$  is  
left behind upon evapora-  
tion. If excess of  $HS$  is present  
the following results

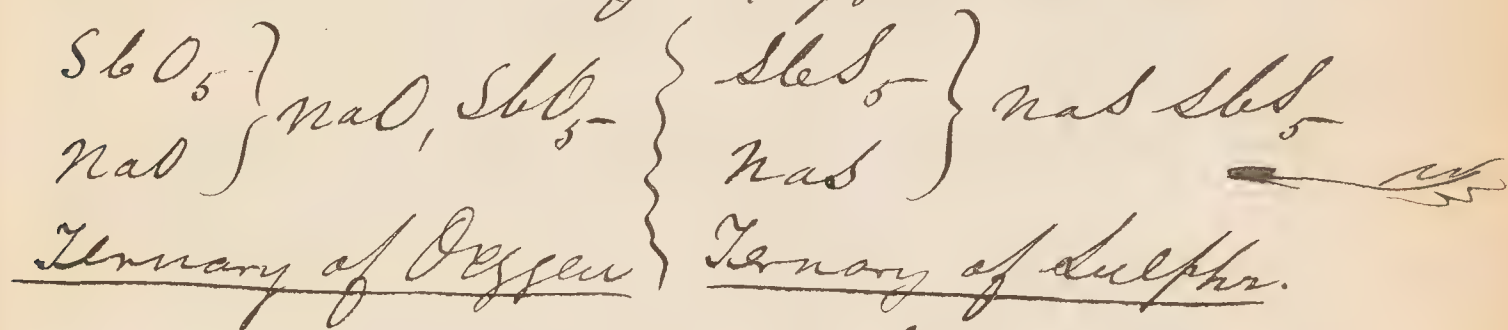


To form Sulph. ides In most cases we can produce a sulphide <sup>by</sup> the use of H.S., & if we wish one from an Oxide - we generally obtain the Corresponding Sulphide to the Oxide.



In this way we can easily convert oxides into the Corresponding Sulphides - whereby, an atom of Sulphur simply replaces an atom of Oxygen - & Water for each atom is formed  
Ex With PbO & KO & AsO}\_3

These Sulphides show the greatest analogy to the Acid Oxides - for they possess the power of combining again amongst themselves, just as the Binaries of Oxygen - thus



Those Oxides which are the strongest bases. viz (those of K. Na, Ca &c) form also the strongest Sulpho-bases & have the power of uniting with acid sulphides ( $\text{AsS}_3$ ,  $\text{S}$ , bases  $\text{SbS}_3$ ,  $\text{AsS}_3$ ,  $\text{SbS}_5$ ,  $\text{SnS}_2$ ,  $\text{SbS}_3$  &c) & acids to form Sulpho Salts - Exp  
 To tell whether we have to do with an acid or a S Base, we have only to bring it into contact with a strong Sulpho base - if it dissolves it is a Sulpho acid - if not - it is a Sulpho-base.



Three We have then three classes  
 Classes of of Sulphur compounds, as we  
 S. Compds. have three classes of Ox-  
 ygen compounds; viz: Sulphuric acid  
S. bases - + S. Salts.

Class. of By means of this various be-  
 metallic behavior to H<sub>2</sub>S, of the metallic Ox-  
 Acids ides we can class the same into  
 groups + separate them ana-  
 lytically. ————— With  
 behavior The class. the sulphides are so sol-  
 with H<sub>2</sub>S ule in acids that H<sub>2</sub>S will

bring about no precipitate —  
 (Fe, Co, Ni, Mn, Ca, Mg, K, Na &c &c)

Another great class will give us  
 insoluble sulphides from acid  
 solutions - + will be divided again  
 into two sub-groups. for they form  
 Acid + basic sulphides - to the  
 former belong As Sb, Sn, Au, Pt &c  
 to the latter belong Cu, Pb, Ag &c -

When they occur together we can sepa-  
 rate them safely by dissolving the  
 acid sulphides in NaOH, K<sub>2</sub>S or NH<sub>4</sub>S

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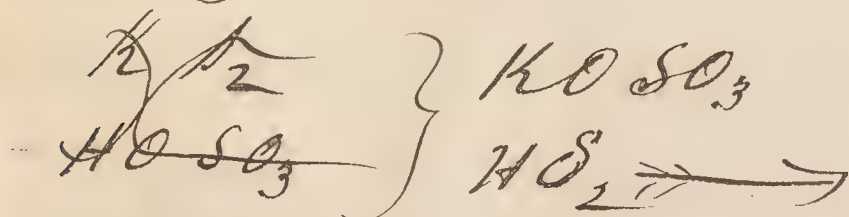
$\text{H}_2$  of  $\text{H}_2\text{S}$  is often given up  
 to a higher oxide + the  $\text{S}$  Reducing  
 thrown down - the Oxide is action of  
 reduced -  $\text{Fe}_2\text{O}_3 \cdot 3\text{SO}_3 \left\{ \begin{array}{l} 2\text{FeOSO}_3 \\ \text{HOSO}_3 \end{array} \right.$   $\text{H}_2\text{S}$   
 $\text{H}_2\text{S} \downarrow$   $\left\{ \begin{array}{l} \text{HOSO}_3 \\ \text{S} \end{array} \right.$  Ex

Wassersstoff Supersulphid - ?  $\text{H}_2\text{S}_2$

We are not

sure that this is the composition  
 of this comp'd - but it is prob-  
 able - If upon  $\text{K}_2\text{S}$  we con-  
 ne to ~~lead~~ <sup>cook with</sup>  $\text{H}_2\text{S}$  - we get  $\rightarrow$

$\text{H}_2\text{S} \left\{ \begin{array}{l} \text{K}_2\text{S}_2 \\ \text{H}_2\text{S} \end{array} \right.$  Afto this Re-sulphid - Mann-  
 is treated with a facture  
 strong acid we get the fol-  
 lowing reaction  $\rightarrow$



We use the fluid  $\text{H}_2\text{S}_2$  to prepare  
 liquid  $\text{H}_2\text{S}$ .

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Its only interesting feature  
Analogy is its analogy to the corre-  
 ponding compound of WurthO  
 viz. Binoxide of Hydrogen

S. + O compds

After these

there exist a great number.

Hypo Sulphurous Acid =  $\text{HO} \cdot \text{S}_2 \text{O}_2$

WurthO →

" " =  $\text{SO}_2$

" Sulphuric " =  $\text{HO} \cdot \text{S}_2 \text{O}_3$

" acid =  $\text{SO}_3$

These are the chief oxides of  
 sulphur - but besides these  
 there are a great number -

As above =  $\text{HO} \cdot \text{S}_2 \text{O}_2$

Tritious acid =  $\text{HO} \cdot \text{S}_3 \text{O}_5$

Tetra thion " =  $\text{HO} \cdot \text{S}_4 \text{O}_5$

Penta " " =  $\text{HO} \cdot \text{S}_5 \text{O}_5$

Each succeeding compd contains  
one more atom of S than preceding.



SO<sub>2</sub> = Sulphurous acid

From this Compd we proceed outward - to consider the formation of all the other com- SO<sub>2</sub> pds - It occurs in nature In Nature in the neighborhood of volcanoes & is formed by volcanic action.

Can be formed by the direct union of S + O - Exp - Bring into a retort a measured quantity of Oxygen

at the bottom of this a piece of Sulphur; heat & volumet- combine the two - al- ric Anal- low the retort to cool, & ys of then read off. It will be SO<sub>2</sub> found that the level of the Synthesis Hg will be the same as before the operation: that is -

773 cc O (gives 773 cc SO<sub>2</sub>) : 1.1056 sh. gr

773 cc SO<sub>2</sub> → 2.2112 sh. gr

Sulphur in 773 cc SO<sub>2</sub> = 1.1056 " "

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$$773^{\text{cc}} \text{S} = 2.2112$$

$$\frac{1}{2} \text{ vol S} = 1.1056 \text{ that is:}$$

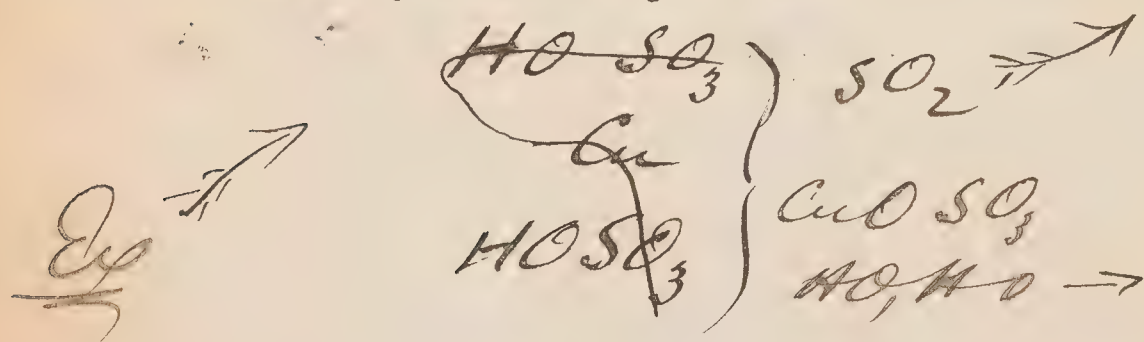
$\text{SO}_2$  is composed of  
1 vol O = 1.1056

Ditto  $\frac{1}{2} \text{ vol S} = 1.1056$

$$1 \text{ vol SO}_2 = 2.2112$$

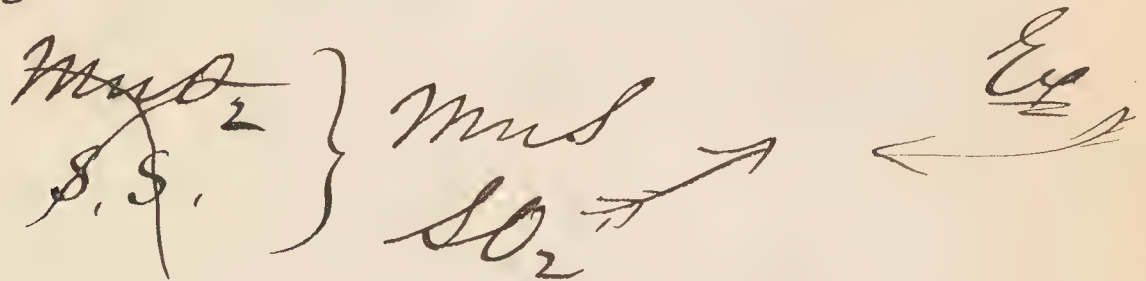
(Or of 2 vols. O + 1 vol S. / to 2 vols  $\text{SO}_2$ )

We generally  
use some other method of  
forming  $\text{SO}_2$  - namely by  
 $\text{Cu} + \text{SO}_3 \text{ HO} - \text{they} -$

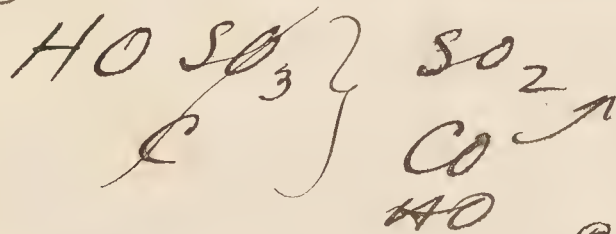


An atom of the O of the  $\text{SO}_3$   
is used to oxidize the Cu -  
Manufacture to CuO - which thereupon com-  
bines with the  $\text{SO}_3$  to form  
 $\text{CuO SO}_3$  & sets  $\text{SO}_2$  free:

Again; we can bring a Super-Manuf-  
Oxide in contact with Sulphur  
& heat

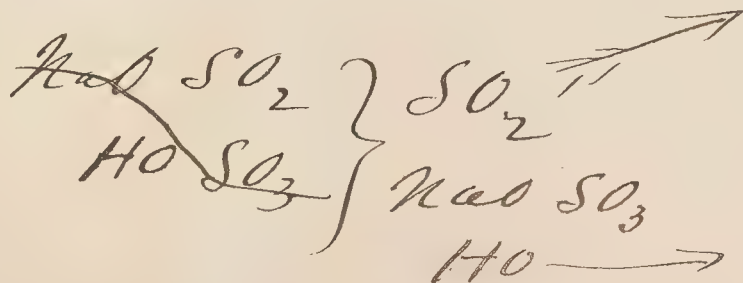


In technique, for the produc-  
tion of hundreds of Pounds  
by letting C, act upon  $\text{SO}_3$ ,  $\text{H}_2\text{O}$ ,



$\text{SO}_2$  is then  
lead into a solution of a strong  
base - & separated from, CO -

From the base it can be again  
be separated by a strong acid





Properties.  $\text{SO}_2$   $\rightarrow$

at  $0^\circ\text{C}$ . it only demands a pressure of  $1\frac{1}{2}$  atmospheres to be condensed to a liquid. Clear & colorless. It combines in this condition with water  $\text{SO}_2 + 15\text{H}_2\text{O}$

It is as a gas - colorless & transparent. possessing an exceedingly irritating odor.

It does not support combustion - being already a consumed body. Sp. Grav. 2.2112

Although a weak acid it reacts strongly acid -

Ex

A reducing agent - It acts strongly as a reducing agent - on acct of its affinity to form  $\text{SO}_3$ ; it takes Oxygen from most substances containing it - with which it comes into contact.

Ex

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It is much used as a bleaching agent for Wollen & silk goods. for straws &c - where it adapts itself better than Cl - Bleaching for the purpose. Here its reducing agency acts - or it enters into combination Exp with the material & thus forms colorless combinations.

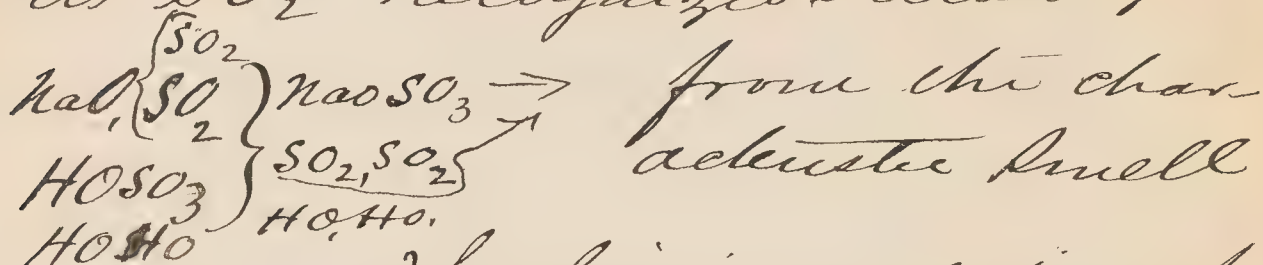
In water  $SO_2$  is very soluble in at  $0^\circ C$ . 68 times its volume is taken up by water.



A tube filled with the Exp Gas. above Hg. if shaken with a small quantity of  $H_2O$ , & again placed above Hg will be, quickly filled with Hg. - from absorption by  $H_2O$

Combines with bases & forms Sulphites. Characteristic in that, when brought into

with a strong acid gives off <sup>it</sup>  
its  $\text{SO}_2$  - recognized instantly

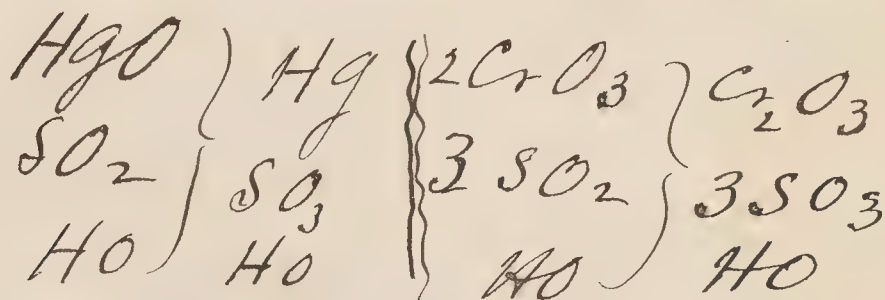


$\text{SO}_2$

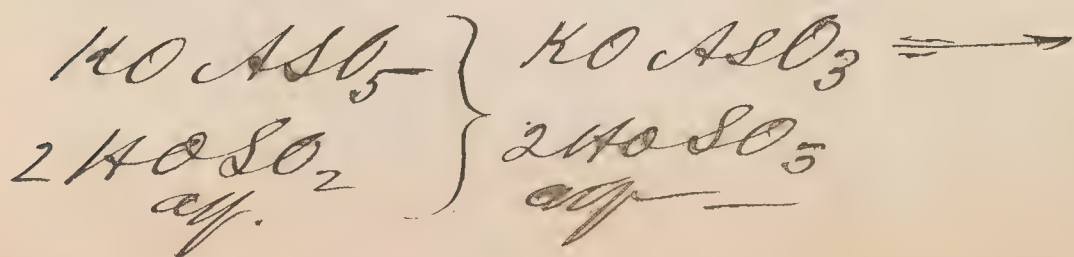
Solution

The liquid solution of  $\text{SO}_2$  possesses all the properties of the gas. It reduces ~~re~~ possesses the ~~at~~ horrid odour. We can easily reduce many metallic Oxides, <sup>to</sup> the metals themselves, or to lower oxides

Ex

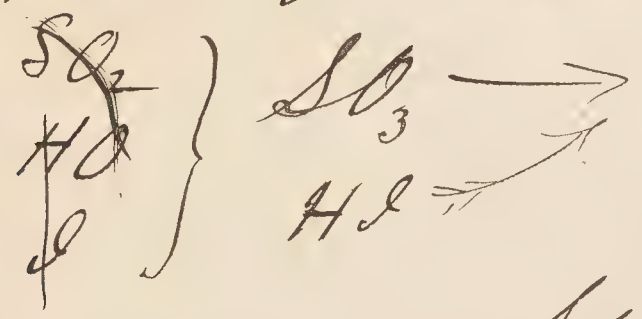


Many salts of acids rich in O. when brought into contact with  $\text{SO}_2$  are reduced to lower oxidized acids — thus



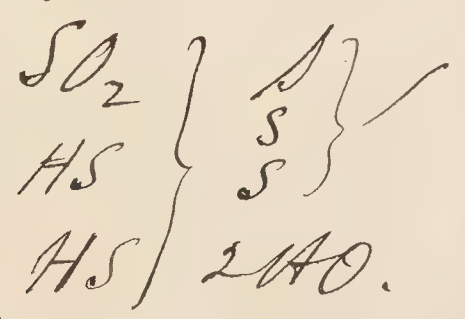


Brought into contact with free Iodine it oxidizes itself to  $SO_3$  at expense of water +  $H_2$  is formed



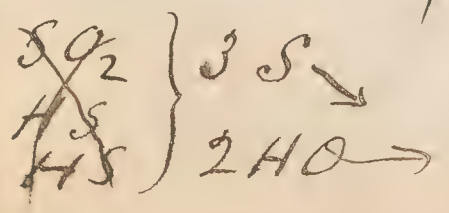
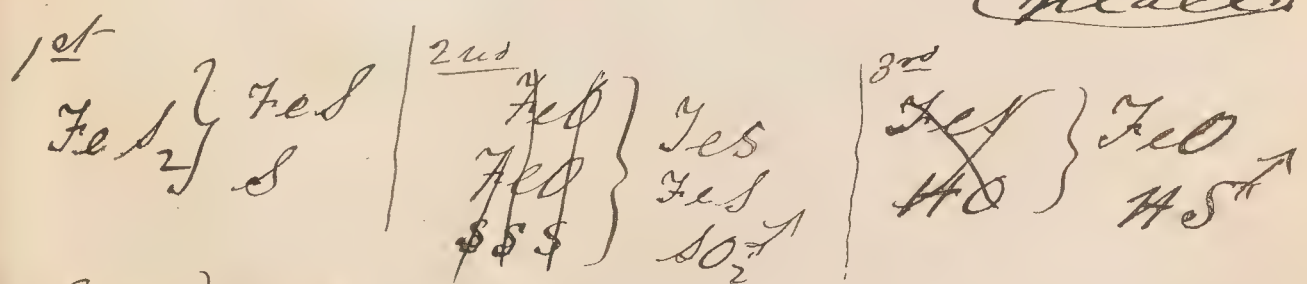
$SO_2$  is decomposed at high temperatures

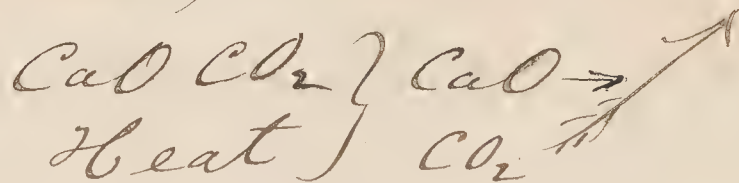
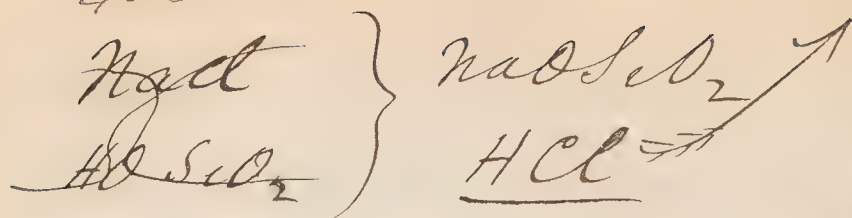
Brought into contact with  $H_2S$  it is decomposed into Exp.  $HO + S$ .



Process of S manufacture in volcanoes

In active volcanoes, the following reactions indicate what takes place (placed)





The above reactions explain also the production of Hydrochloric & Carbonic Acids, which are always so richly formed in volcanoes.

How can we determine the amount of  $\text{SO}_2$  in a fluid?

Quant. Russen's Method - If we bring  
 titatune a solution of Iodine into con-  
 Analysis tact with a solution of  $\text{SO}_2$  -  
 of  $\text{SO}_2$  it forms  $\text{SO}_3$  &  $\text{HI}$  - when this  
 decomposition is complete -  
 free Iodine will be in the fluid  
 & will give us a reaction  
 for the slightest quantity -  
 if we have present in the  
 liquid, a solution of Starch

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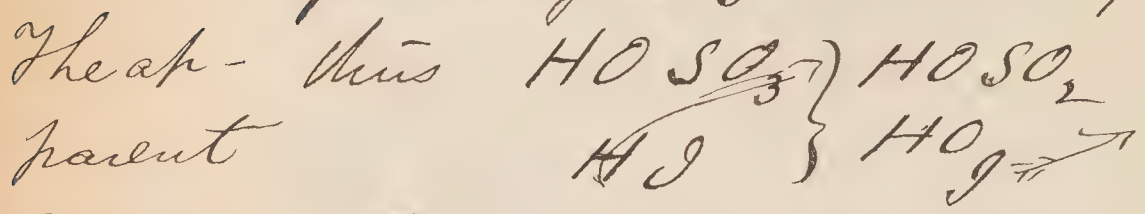
If we know the amount of Iodine we have used to exactly convert the  $SO_2$  to  $SO_3$  we can calculate with certainty the amount of  $SO_2$  -

We prepare for ourselves a solution of I in KI which shall contain a known quantity of I for each C.C. (call this quantity for 1 C.C.  $\alpha$  - for  $t$  - Burette graded quantity of I =  $t\alpha$  If ~~we~~ to an unknown quantity of  $SO_2$  we cautiously add our Eq standard solution of I - the point of perfect change into  $SO_3 + H_2O$  will be indicated to a drop by Starch of I in excess - which will be colored ~~by starch~~ blue. we then have the proportion.  $I : SO_2 = \alpha t : x = SO_2$   
 $\alpha t \frac{SO_2}{\alpha} = SO_2$  to be determined -

This method is exceedingly sharp - & by far the best for the purpose.



It has been previously men-  
tioned that Iodides were decom-  
posed by  $\text{SO}_3$  + I set free -



Contra-  
dictory  
Conduct  
of  $\text{HI} + \text{SO}_3$

The reaction here mentioned  
does actually occur - but  
only when  $\text{HIO SO}_3$  +  $\text{HI}$  are  
present in concentrated solu-  
tions - but when the amount  
of  $\text{SO}_2$  in the solution is not  
greater than 3 or 4 parts in  
10000 - the contrary reaction  
takes place +  $\text{SO}_2$  is oxidized  
to  $\text{SO}_3$  +  $\text{HI}$  is formed.

It is here seen that 2 contrary  
reactions take place - accor-  
ding as the fluid in which the  
decomposition is to take place  
is, or is not concentrated.

By this means we are not only able to determine the amount of  $\text{SO}_2$  but also the Iodine in an unknown solution - : & not only Iodine - but of all substances which set Iodine free : i.e. - Cl. Br. &c. - & hence to determine the amount of any Super Oxide - or high Oxide which will set Cl free  $\text{MnO}_2$  -  $\text{CrO}_3$  &c. &c. The method will form the subject of the next lecture.

Analyses which  
may be carried  
out

Lecture 49<sup>th</sup>

Bunsen's Quantitative determination  
method of I. Cl. Br.  $MnO_2$  -  $CrO_3$  &c  
 Sog. Iod-titrating.

→ We can easily  
 reverse the operation and  
 determine I & Cl. Method.

We have only, from a standard I solution, to determine the amount of  $SO_2$  in a given volume of  $SO_2$ . We know now the quantity of I necessary to decompose any given quantity of  $SO_2$ .

If now, we have an unknown solution containing Iodine. We have only to bring enough of the  $SO_2$  solution to it, until the color of the free Iodine disappears - then add starch, & titrate it with a standard



solution of I until a bluing occ  
 takes place. We know how much  
 Iodine necessary to bring about  
 a complete decomposition of the  
 $\text{SO}_2 + \text{I}$  from our first research,  
 we fixing the value of our stan-  
 dard solution, & we know the  
 amt of Iodine, from our stan-  
 dard solution, that we were obliged  
 to add to our unknown Iodine  
 quantity to decompose the  $\text{SO}_2$ . Let-

$d$  = amt of (standard) in 1. c.c.

$t$  = number of c.c. added from Burette.

$n$  = number of cylinders used.

$t'$  = number of Burette grades added  
 in the second titration,

Then,  $dt = x + dt'$ , where  $x$  = the

or, for  $n$  cylinders  $\text{SO}_2$  { unknown quantity  
of Iodine.

$nat = x + dt'$ , or - generally - Formu.

for the value of  $x$  for any la for  
 number of cylinders of  $\text{SO}_2$  I determine

$$x = d(nt - t')$$

Let We can also determine the  
~~determine~~ amount of Cl in an unknown  
incubation compo. the process is founded  
 upon the fact that when

Cl when added to an Iodide will  
 separate an equivalent quan-  
 tity of I, & a Chloride is formed  
 the formula is



$$\frac{Cl}{I} \times (wt. I) = Cl.$$

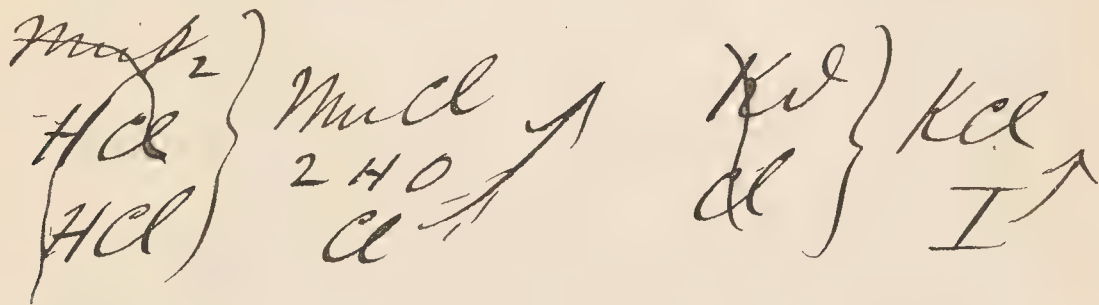
where the same quantities  
 & the same values are placed  
 upon them as in the simple  
 formula for Iodine.

In the same

Br- way we can determine Bromine  
~~determine~~ the only variation being  
incubation in substituting for the atom-  
 ic weight of Cl - that of Br.

$$I : Br :: (wt. I) : x \text{ or } x = \frac{Br}{I} \times (wt. I)$$

We can likewise determine the value of any substance  $MnO_2$  which gives off Cl. or Br.  $\frac{MnO_2}{2}$   
 For example



One atom of  $MnO_2$  separates one atom Cl. One atom of Cl separates one atom I - that is, one atom  $MnO_2$  separates one atom I. Or:

$$I : MnO_2 = a(nt - t_1) : x$$

$$x = \frac{MnO_2}{I} a(nt - t_1).$$

Besides this we can determine any substance quantitatively which can be made to give off Cl. Br. or in a fixed proportion.



Exp

Carry out  
the an-



alysis, we use the one figured here.

Consisting of a retort held with its mouth bulb upward & filled to its second bulb with  $KI$  solution; in this fits loosely - a flask, containing the weighed amt of  $MnO_2$  + ( $HCl$ , is poured upon it) by means of the tube a, furnished in its turn at the other end with a valve preventing the liquid from entering the tube - Heat is applied (after all the air has been driven out by  $CO_2$ ) & the Chlorine passes into the  $KI$  solution & sets  $I$  free - the operation is continued till finished, & the calculations made.



Anhydrous acid =  $SO_3$

Basic Water =  $HOSO_3$

not " " =  $HOSO_3, HO$

" " " =  $HOSO_3, 2HO$

Crystalline =  $HOSO_3, SO_3$

Sulphur turns to  $SO_2$  -  
which in solution gradually  
takes another atom of O +  
forms  $SO_3$  Main

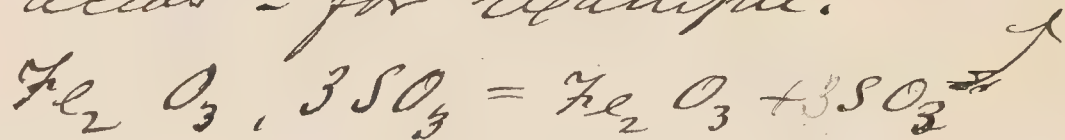


An electric stream passed factu  
through a mixture of  $SO_2$   
+ O, forms  $SO_3$  - not prac-  
tical, This gives us a Eq  
method of determining the  
composition of  $SO_3$  + obtain  
2 vol  $SO_2$   
1. vol O  
1 vol  $SO_3$ .

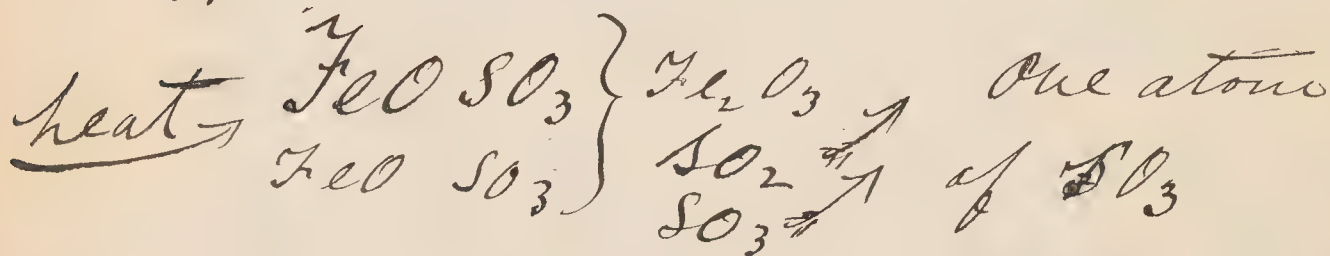
from the Experiment just  
performed —————>

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Manuf. Some sulphates when heated  
 act - simply fall apart into Bases  
 + acids - for example.



or



This method is now abandoned  
 & a simpler one is now adop-  
 ted. From  $\text{K}_2\text{O} \cdot \text{SO}_3 \cdot \text{SO}_3 \} = \text{K}_2\text{SO}_3$   
 $\text{SO}_3$

Such anhydrous  $\text{SO}_3$  - a  
 white solid - crystallizing in nee-  
 dles - great affinity for water.

Melting point  $21^\circ\text{C}$ .

Exp

A vessel of this solid opened.  
 to the air pours out, thick  
 voluminous clouds of  
 $\text{SO}_3\text{HO}$ , in vast quantities.



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This is due to its intense af-  
finity for moisture - for  
which it has ( $PO_5$  excepted) Exp  
the greatest affinity of all  
substances - If you pour some  
of this solid - a few drops  
of water is poured - the  
most intense heat, & violent  
action is noticed as though  
the substances were boiling

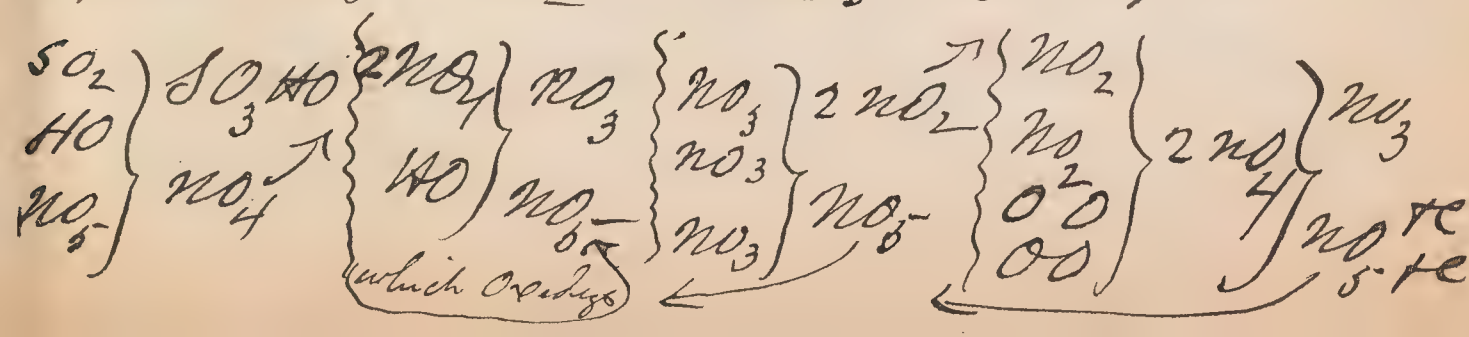
Ex Anhydrous  $\text{SO}_3$  possesses the property of combining with anhydrous bases to salts - , Lead anhydrous  $\text{SO}_3$  over Dry  $\text{BaO}$ . (burns with a brilliant glaz). Two burned bodies combine to form a third.

Anhydrous  $\text{SO}_3$  combines with S. in two proportions a brownish & a blue colored compd. what the compds are are not known.

$\text{SO}_3$  has an intense affinity for water & forms by its union with  $\text{HO} - \text{HOSO}_3$  - every union of  $\text{SO}_3$  with  $\text{H}_2\text{O}$  being attended with the evolution of Heat; at times (according to concentration) intense.

On a large scale  $\text{SO}_3$  is manu-  
factured from S. (So in England  
+ America). The sulphur is burn-  
ed in presence of air + the fumes  
of  $\text{SO}_2$  - lead by means of large (Main-  
facture of  $\text{SO}_3$   
the fumes of  $\text{SO}_2$  are brought into  
contact with those of  $\text{NO}_3$  - + with  
vapor of water - the following  
reactions indicate the process by  
which the  $\text{SO}_3$  is formed.

The principle is that  $\text{NO}_3$ -in pres-  
ence of  $\text{H}_2\text{O}$  vapor-oxidizes  $\text{SO}_2$  to  $\text{SO}_3$   
& is reduced to  $\text{NO}_4$ - 2 atoms of  
 $\text{NO}_4$  fall apart into  $\text{NO}_3 + \text{NO}_3$ -  
 $\text{NO}_3$  is decomp. instantly into  $2\text{NO}_2 + \text{NO}_3$ -  
 $\text{NO}_2$  in contact with air forms  $\text{NO}_4$  which  
is in turn decomposed to  $\text{NO}_3 + \text{NO}_3$  & so  
the process goes on - the  $\text{NO}_3$  <sup>formed</sup> in every  
case oxidizing  $\text{SO}_2$  to  $\text{SO}_3$ . Thus-





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Distillation of  
 $\text{SO}_3 + \text{H}_2\text{O}$

If  $\text{SO}_3 + \text{H}_2\text{O}$  be distilled, supposing it to be a dilute acid - at first only  $\text{H}_2\text{O}$  - then a more & more concentrated acid distills over: while the Boiling point constantly rises. When the acid in the retort has the concentration of  $\text{SO}_3 \cdot \text{H}_2\text{O}$  nearly (Boiling pt  $338^\circ\text{C}$ ) -  $\text{SO}_3 \cdot \text{H}_2\text{O} + \text{SO}_3$  distill over & give us  $2 \text{SO}_3 \cdot \text{H}_2\text{O}$  - crystallizable at  $0^\circ\text{C}$ .

→ Properties of the Manufactured acid are as follows. a transparent colorless liquid, which does not freeze. which attacks organic substances taking from them  $\text{H}$  &  $\text{O}$  elements & leaving  $\text{C}$ .  
Such an affinity for moisture that, on being mixed with it - intense heat is produced.

It can take, when concentrated, take up 15 times its weight of watery vapor from the air. hence  $\text{SO}_3$  is an excellent dessicating agent.

When mixed with 4 times its weight of Ice - a considerable amt of  $\text{SO}_3$  cold is produced - explanation, with a liquid comp'd of  $\text{SO}_3 + \text{H}_2\text{O}$  is formed - Ice mixed with the ice in passing from <sup>solid</sup> ~~liquid~~ to <sup>liquid</sup> ~~solid~~ state - requires much heat Ex to remain liquid - this heat it must abstract from the  $\text{SO}_3$  + hence - the cold produced). When mixed with an equal amt of Ice, (better 4  $\text{SO}_3$  to 1 ice) heat is produced - (because of the chemical combination) for the heat rendered latent by the ice in becoming liquid is not enough to absorb the heat rendered by the chemical combination -

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 $\text{SO}_3$   
in

$\text{SO}_3$  is a very strong acid. & possesses the property of dri-

Compounds

ving from compounds almost every other acid. & always to drive out <sup>from</sup> a compound whose acid are volatile under that of  $\text{SO}_3$  itself. It forms many double salts - of great importance; thus

$\text{KO SO}_3$  }  
 $\text{HOSO}_3$  } Bi Sulphate of KO.

The alums of great crystallographic importance having the following Zusammensetzung

$(\text{KOSO}_3)_2(\text{Al}_2\text{O}_3 \cdot 3\text{SO}_3) + 24\text{H}_2\text{O}$

$(\text{NH}_4\text{O}, \text{SO}_3), (\text{Al}_2\text{O}_3 \cdot 3\text{SO}_3) + 24\text{H}_2\text{O} \text{ &c.}$

Gypsum

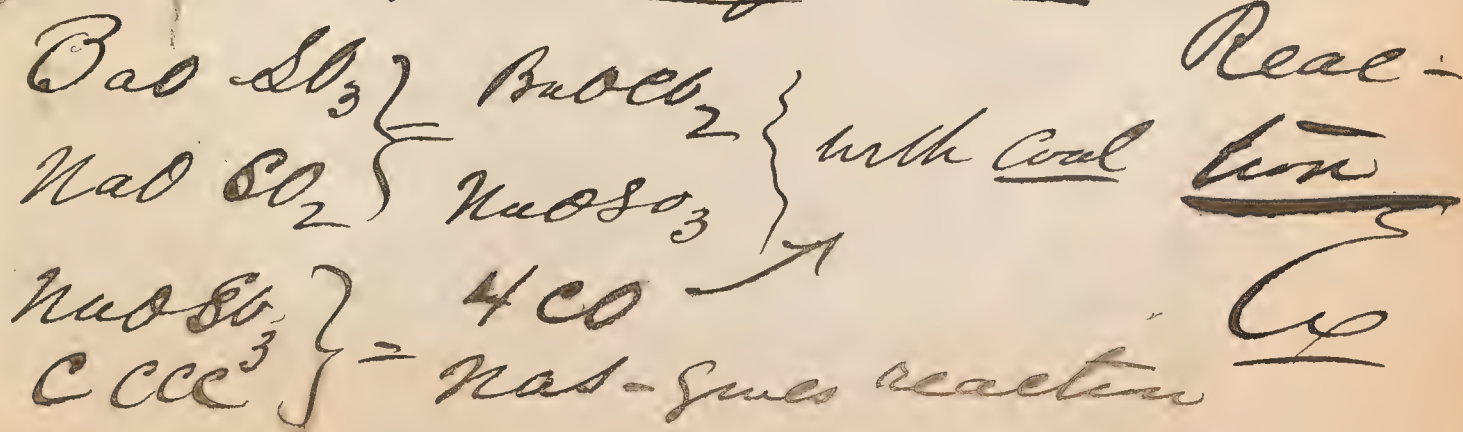
As  $\text{CaOSO}_3 - \text{SO}_3$  enters into a compound widely spread in nature, occurring in great beds with ~~raft~~ & independ. of it.



# Reactions with the General Reagents

| <u><math>\text{AgNO}_3</math></u>                                           | <u><math>\text{PbO}_2</math></u>                                                                           | <u><math>\text{BaCl}_2</math></u>                                                                                                                                     | <u><math>\text{CaCl}_2</math></u> |
|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| gives no reaction, as the salt $\text{Ag}_2\text{SO}_3$ is <u>soluble</u> . | a white precipitate of <u><math>\text{PbSO}_3</math></u> Soluble in $\text{NO}_3^-$ + in. Soluble in Water | Characteristic precipitate of <u><math>\text{BaSO}_3</math></u> - <u>insol.</u> in even tolerably concentrated acids - Decomposable by fusion with Carbonated alkalis |                                   |

All the  $\text{SO}_3$  salts when mixed with ~~Silver~~ +  $\text{Na}_2\text{CO}_3$  upon Coal, are reduced by the Carbon to  $\text{Na}_2\text{S}$  - which upon Silver brings about a black stain, upon the formation of a sulphide of Silver

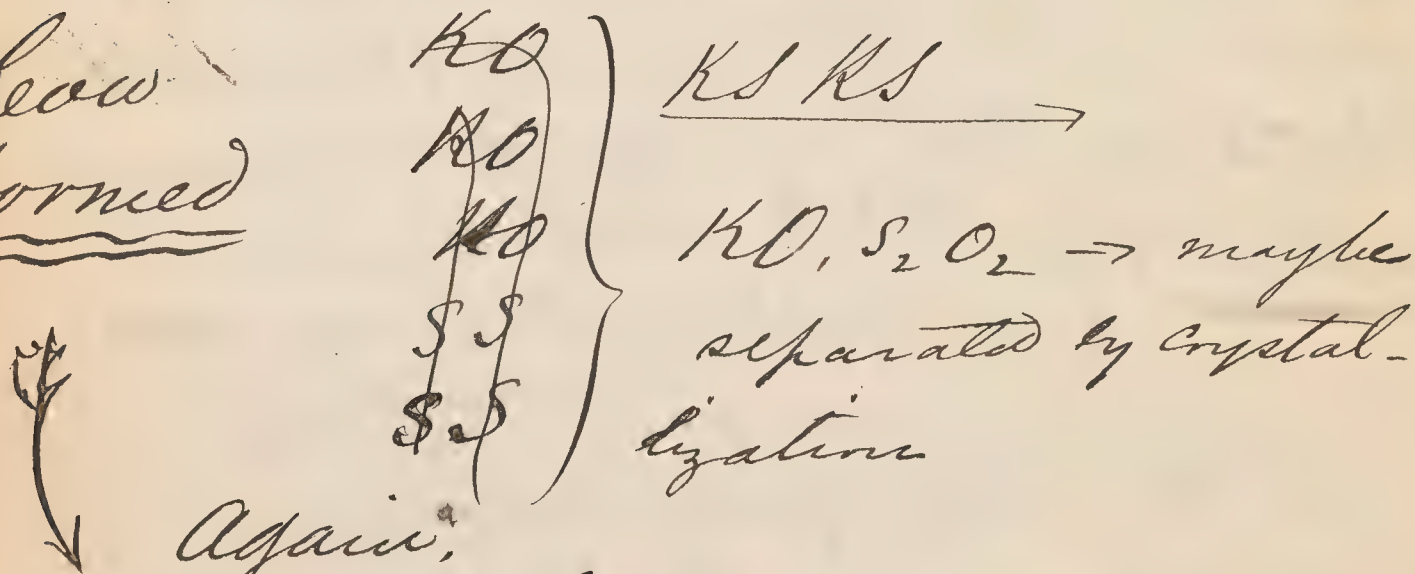


471 Hypo-Sulphurous Acid.  
 $\underline{S_2 O_2}$

It cannot be obtained for itself but instantly decomposes.

The  $H_2 O_2$  salts are formed like  $ClO$  salts &c.

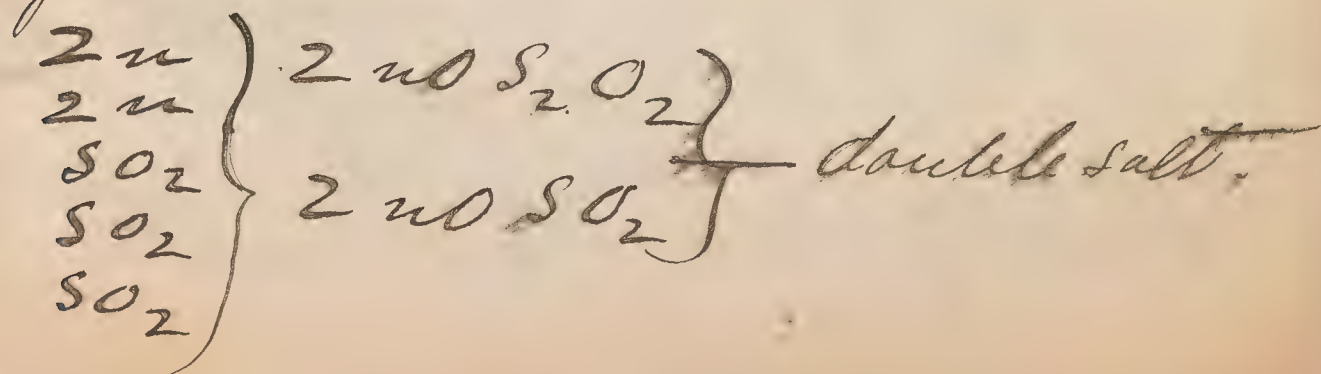
How formed



Again,

Ba S, HS brought into contact with atmospheric air forms  $Ba S HS \} BaO S_2 O_2$   
 $SO_2$  }  $H_2 O$

All Sulpho bases strong - behave similarly. Bring  $SO_2$  in contact with



## Lecture 57<sup>st</sup>

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By diss.

Bring  $\text{NaO SO}_2$  with a moderate  $\text{S}_2\text{O}_2$   
ately large quantity of S - the  
 $\text{SO}_2$  takes up another atom Mann-  
of S  $\text{NaO SO}_2 \} \text{NaO S}_2\text{O}_2$  facture

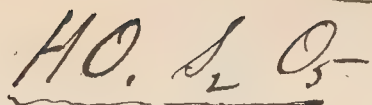
By treating with a strong  
acid -  $\text{S}_2\text{O}_2$  salts are always  
decomposed into S &  $\text{SO}_2$

If we bring  $\text{AsO}_3$  into Exp  
contact with  $\text{S}_2\text{O}_2$  in statu  
nascenti - the following re-

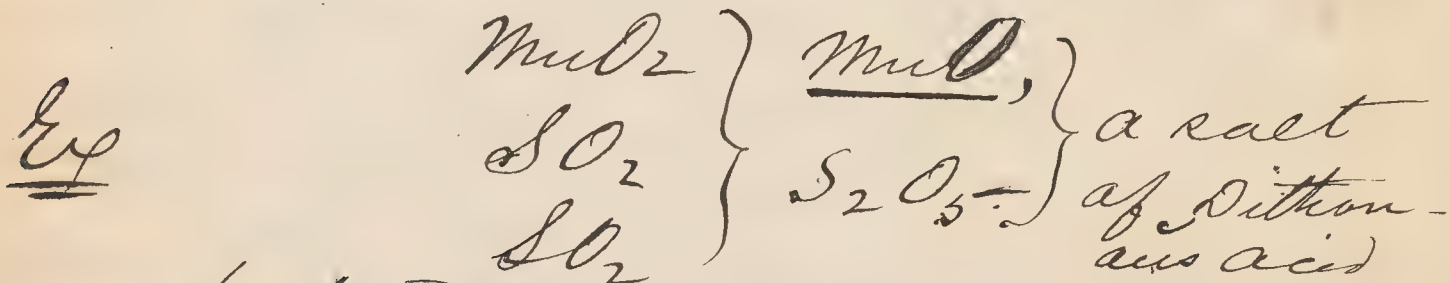
sults  $\text{AsO}_3 \left\{ \begin{array}{l} \text{As S}_3 \\ \text{SO}_3 \\ \text{S}_2\text{O}_2 \\ \text{SO}_3 \\ \text{SO}_3 \end{array} \right.$  use as a  
Reagent

It can  
therefore be used as a general  
reagent for precipitating  
the sulphides in place of H.S.



Dithionic acid.

If we allow  $\text{SO}_2$  act upon  $\text{MnO}_2$ , the following takes place

Manufacture

From this salt

we can separate the acid as follows - add to this salt a solution of  $\text{Ba S}$  + we obtain  $\text{MnS} + \text{BaO, S}_2\text{O}_5^-$ , the latter a soluble salt, to this we can by removing  $\text{BaO}$  by  $\text{H}_2\text{S}$  obtain the  $\text{S}_2\text{O}_5^-$  free

may  
be

Isolated →

The acid forms a number of soluble & crystallizable salts, by great concentration the free acid falls apart into  $\text{S} + \text{SO}_2$ .

By glowing the following is  
 the process.  $\text{NaO}, \text{S}_2\text{O}_5 - \left\{ \begin{array}{l} \text{SO}_2 \\ \text{NaOSO}_3 \end{array} \right.$   
 glowing

A characteristic distinction  
 between  $\text{S}_2\text{O}_2 + \text{S}_2\text{O}_5$  Distinct  
 $\text{S}_2\text{O}_2$  upon heating or de- tion bet-  
 composing forms  $\text{S} + \text{SO}_2$  tween  
 $\text{S}_2\text{O}_5$  salts give off  $\text{SO}_2$   $\text{S}_2\text{O}_2 +$   
 but leave behind them  $\text{S}_2\text{O}_5 -$   
Sulphates.

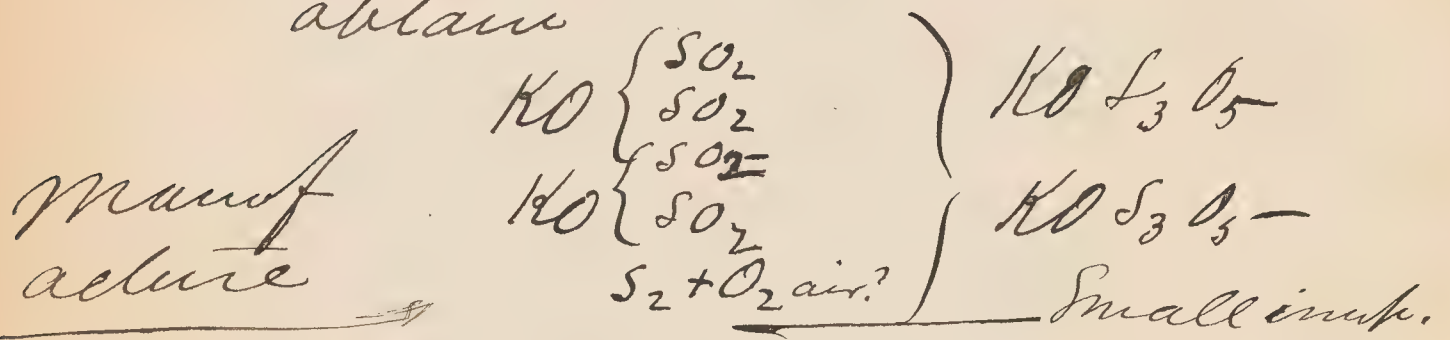
There are besides these acids  
 a homologous row of S+O Compds  
 $\text{HO}, \text{S}_3\text{O}_5 = \text{Trithion acid}$   
 $\text{HO}, \text{S}_4\text{O}_5 = \text{Tetra thion} \quad 4$   
 $\text{HO}, \text{S}_5\text{O}_5 = \text{Penta} \quad " \quad 4$

Compounds possessing only  
 a theoretical interest, as  
 compds of S+O, but prac-  
 tically of not the least  
 importance.

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If we digest  $KO, 2SO_2$  with Sulphur? we obtain



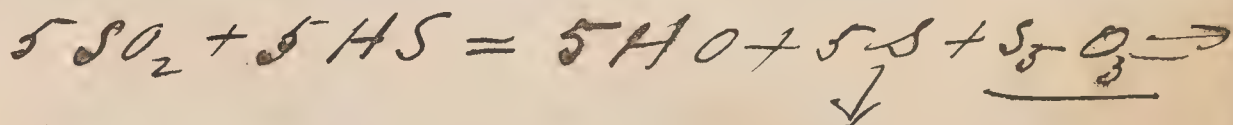
If we bring water into contact with  $NaOS_2O_2$  the following results -

Ex  $2 NaOS_2O_2 \} NaOS_4O_5$   
 $NaOS_2O_2 \} NaS$

gives very prettily crystallizing salts. Cannot be separated for it decomposes.



Manuf. - If into a saturated solution of  $SO_2$  in  $H_2O$ ,  $HS$  gas be lead the compound will be formed.





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↓ ↓

SSS  
JJJ

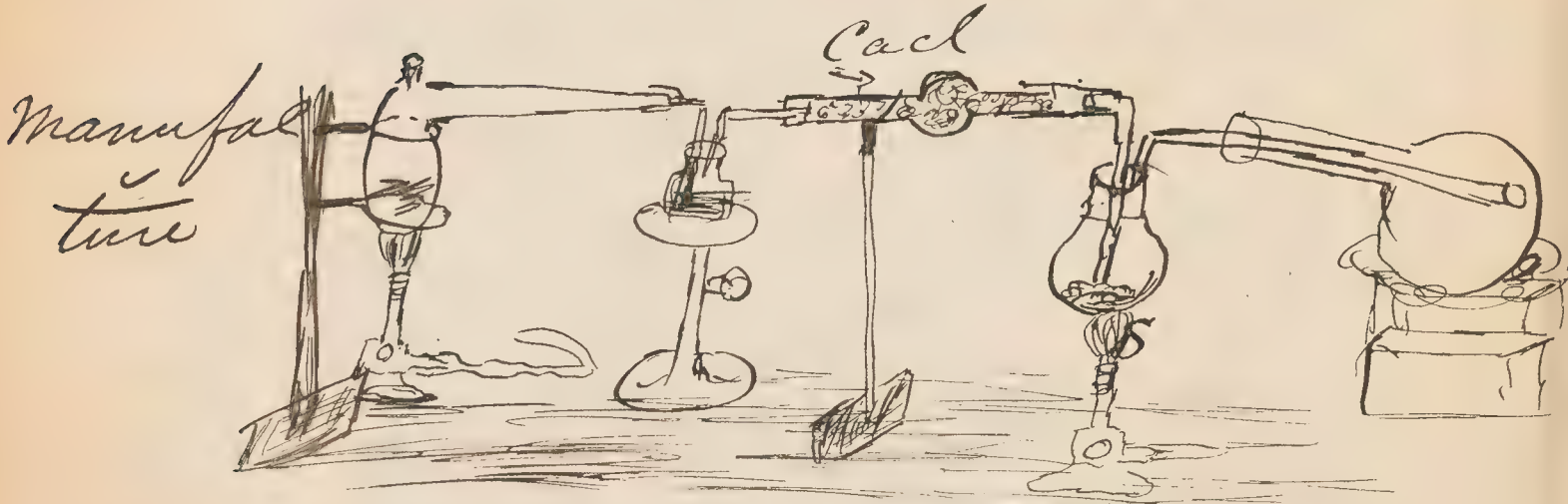
Their  
Decompo-  
sitions

time analysis can only allow  
us to separate them - The quantity  
of separated sulphur - of SO<sub>2</sub>  
& of the sulphate which remains  
behind must be carefully  
made.

S + Cl. compounds

$S_2 Cl = \frac{1}{2}$  Chlor. Schwefel

$S. Cl =$  Chlor. Schwefel.



$Cl_2$  A reddish fluid of intensely disagreeable smell. sp. gr. = 1.687. Will not mix with  $H_2O$  but sinks - & gradually decomposes itself - an excellent solvent for Sulphur. Formed by direct union of S + Cl. the Sulphur present in excess.

$ClS$  - Formed in the same way - when Cl is in excess. - (that is by leading Cl gas over  $ClS_2$ )  
A dark red fluid - of the specific gravity = 1.625 - easily decomposed into Cl + S.

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$Cl_2$  is used much - in re-  
storing the color + consist-  
ency to Caouchouc - after  
being perforated at high temps.

S + Br. + I.

Formed in  
a similar manner - + of  
small importance -

## Selenium.

A body very  
sparsely scattered in nature -  
Discovered in 1818 by Ber-  
zelius. In nature; comes in  
some Sulphides,  $FeS_2$  &c in  
very small quantities. When S is  
manufactured from these Sulphides -  
the  $SO_2$  fumes are lead through  
long + wide tubes, + the  $SeO_3$  &c  
condenses upon the sides of  
them as such(?) + in Comb. with Bases?



It occurs independently as  $PbS_2$  - but exceedingly-rare. also as  $HgSe$  - &  $PdSe$ . But generally where Se occurs it is with Sulphur.

It is manufactured from the  
Man-  
 ufacture residues of  $SO_3$  manufacture. The Schlam is smelted with  $Na_2CO_3$  to separate the bases, &  $Na_2SO_3$  &  $Na_2SeO_3$  ( $Na_2SeO_3$ ) This is heated with  $HCl$ , & then  $Cu_2Cl$  is added & the Se separates as red Selenium. by warming the whole amount of Se is separated in a tolerably pure state. From the Kiese  $FeS_2$  &c it can be manufactured in the same way. by first oxidizing with  $H_2O_2$ .

Lecture 5<sup>th</sup> 2<sup>nd</sup>.

## Properties of Se.

Possesses greatest analogy to S. in that it exists in two modifications - crystalline + amorphous. ( $\alpha$  +  $\beta$  modifications). First is obtained by smelting + cooling rapidly. amorphous - 2<sup>nd</sup> - by retaining it for some time at a temperature of  $120^{\circ}$  - crystalline + having the property of - Properties  
 Conducting Electricity.  
 Smelts at  $200^{\circ}$ . At  $700^{\circ}$  converted into a brown red vapor - & under favorable conditions condenses itself again - It gives out at the same - a peculiarly disagreeable smell which is characteristic for this substance - viz. "Faulende Rettig"

Exp

By heating this Se in a slow stream of  $O_2$  - it burns with a pale blue flame like S., & the resulting comp'd, is  $SeO_3$  - a solid.

Test  
for  
Se

Exp

Metallic Se possesses one property by which it can readily be detected - & separated from a substance which possesses the most extraordinary analogy to it. viz - the property of being dissolved in concentrated  $SO_3$  with a blue green color - When the solution is diluted with  $H_2O$ , the Se is separated again in the form of a reddish - finely divided powder - This is the most characteristic reaction for Se.



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Analogous to S it forms Se  
Selenides - which possess  
acid or basic properties - or  
these can unite amongst  
themselves again, just as the  
Sulphides to form Salts.

Greatest analogy to H.S. the H.Se.  
same smell - + even a  
greater decomposibility -

Formed in the same manner as  
H.S. viz: - by the decomposition  
of some Selenide - by a dilute acid, or better - by heat -  
using metallic Se - in a dry Sulphide  
+ fine stream of H. the gas must be caught above  
Hq. In all its properties it  
has a surprising analogy to  
H.S. Most of the Selenides -  
possess the same color +  
such singular analogy to the  
Corresponding Sulphides -  
that it is only by a careful  
Analysis that we can destroy it.

## Oxides of Se.

Just as Sulphur - so Se  
forms two analogous Oxides  
 $SeO_2 + SeO_3$

$SeO_2$  The first is identical almost  
in its properties + corresponds  
throughout to  $SO_2$  - the  
 $SeO_3$  latter to  $SO_3$ .

### $SeO_2$

Is a white, crystalline powder  
formed by the combustion  
of Se in O or in air - conver-  
tible into a green gas.

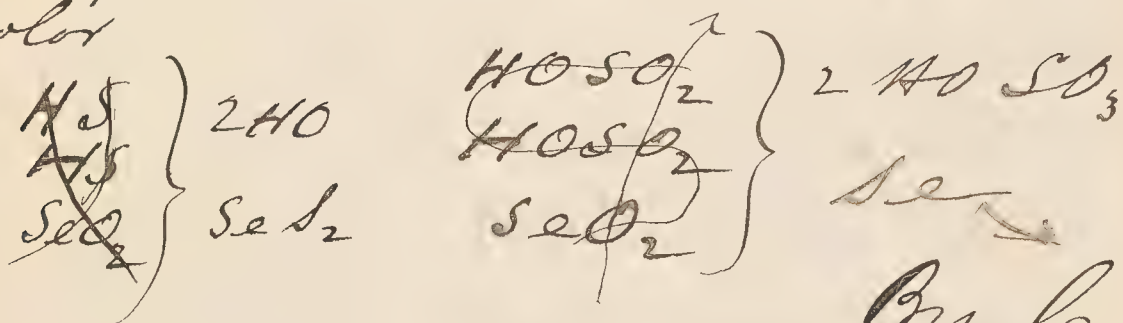
It is readily soluble in  $H_2O$ ,  
& by the use of reducing a-  
gents Fe. Cu Zn,  $SO_2$  &c &c  
can be reduced to Se.

It forms salts many of them  
crystallizing beautifully.

Analogous in everything  
to the corresponding Oxide of S.

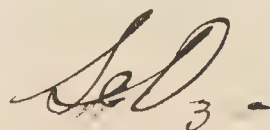
$\text{SeO}_2$  Salts are precipitable yellow by  $\text{H}_2\text{S}$ . - forms a sulpho Exp  
 acid. soluble in  $\text{K}_2\text{S}$ .

Reduced to  $\text{Se}$  by  $\text{SnCl}_2$  - or  $\text{SnCl}_4$   
 or  $\text{SO}_2$  - in the form of a  
 finely divided powder of red-  
 color



By  $\text{C}$ .

Before the blowpipe - it  
 is reduced to  $\text{Se}$ . Before  
 the gas flame. in the reduce. Exp  
 two flame, we can get the  
 red deposit upon porcelain.  
 This can be dissolved in  $\text{SO}_3$  Test.

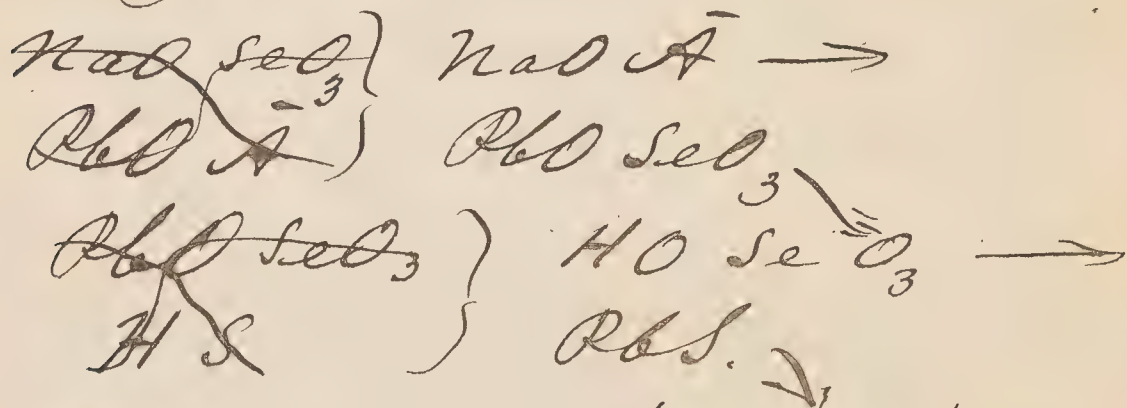


Oxidizing  $\text{SeO}_2$   $\text{NaO}$  - with  
 $\text{NO}_3$  - or  $\text{NaO ClO}_4$ ,  $\text{NaCl}$ , the  
 salt  $\text{NaO SeO}_3$  is somewhat



insoluble ~~with~~ at  $33^{\circ}\text{C}$ , +  
at this temperature crystals  
go out.

From this salt we may  
obtain the acid by forming  
the  $\text{PbO}$  salt, + then precip-  
itating this with  $\text{H}_2\text{S}$ . thus -



Distinguish (By treating a  $\text{SeO}_3$   
between salt with  $\text{HCl}$  -  $\text{SeO}_2$  salt  
 $\text{SeO}_3 + \text{SO}_3$  is formed +  $\text{Cl}$  is given off  
 $\text{HCl} + \text{NaO SeO}_3 =$   $\nearrow$   
 $\text{NaO SeO}_2 + \text{HO} + \text{Cl}$

This  $\text{SeO}_2$  can either be precip-  
itated with  $\text{H}_2\text{S}$  - yellow - which

$\text{SO}_3$  salts never do - Or - by the  
(By Heat. use of reducing agents the -  
ing to above salt can be entirely decomposed  
 $285^{\circ}\text{C}$ . + metallic seleminum separated (?)  
 $\text{SeO}_2 + \text{O}_2$   
formed

The salts of  $\text{SeO}_3$  form all of them, if they crystallize at all - isomorphous with  $\text{SeO}_3$ . When cooked with  $\text{HCl}$  for some time - the salts of  $\text{SeO}_3$  are converted into  $\text{SeO}_2$  salts - with a swing off of  $\text{Cl}$  - then the salt gives the precipitate with  $\text{HS}$  - which  $\text{SeO}_3$  will not give.

### Se + Cl.

There are two compounds.  
one ratio  $\text{Se Cl}_2$  crystallizes in needles -  
 $\text{Se}_2 \text{Cl}$  - which is fluid -  
+ analogous to  $\text{S}_2 \text{Cl}$ .

### Tellurium -

Even more rare than Se found most exclusively in certain districts in Hungary with  $\text{Au}$  -  $\text{Ag}$  +  $\text{Pb}$  ores.

Discovered in 1782 by Müller  
In the slag & refuse of  
the flues in manufactures  
the metal can be obtained

Manu- If these refuse matters are  
factors treated with Aqua regia.  
& then reduced with  $\text{SO}_2$  -  
the metal is formed.

Purified by distillation in H.  
Physical Properties.

A bluish white color. & a remark-  
able metallic lustre - Sp. Gr. -  
6. +. (HO = 1) - Can be volatilized  
again condensed like se & ed.

Exists in a crystalline, & in an

Mon-  
aly of Amorphous Condition.  
the Phys- Stands upon transition ground  
ical & between a metal & metallized  
Chemical source Chemists classing it  
Bapt' with the former - Its affinity  
of in chemical properties induce  
H the majority to class it with Sulphur.



Heated in a stream of Oxygen it burns differently (with a green flame) to  $\text{TeO}_2$  a white solid - analogous in its properties to  $\text{SeO}_2 + \text{SO}_2$ .

Metallic Te is likewise soluble in Concentrated  $\text{SO}_3$  - but with a fine Carmine red color - diluted with  $\text{H}_2\text{O}$  Ex the Te - ~~the~~ is thrown down as a black powder.

In both these cases with Te + Se - the treatment with  $\text{SO}_3$  gives a true solution of the metal in the acid. & the reaction here mentioned - is by far the best to distinguish between the substances  $\text{S} + (\text{Se} + \text{Te})$ .

Of the two last substances however to occur together in a

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solution the method of detecting both is as follows.

Make the solution in conc.  $\text{SO}_3$

Distinguishing between Fe + Se - & the color, (if Fe is present) will show a reddish tint. by heating the solution. the Fe will decompose the  $\text{SO}_3$  & form  $\text{FeO}_2$  which goes off &  $\text{SO}_2$  detts, then remains behind only Se deposited in  $\text{SO}_3$  with the greenish color - with  $\text{H}_2\text{O}$  the reddish color of separated Se will become apparent.

The Hydrogen Compound is brought about in the same way as with S. + Se. It in a H<sub>2</sub>O solution gives precipitates analogous to the Sulphides but mostly darker in color. It is just as decomposable as HSe.

Tellurium + O.

There are 2 Compds.

TeO<sub>2</sub> = Tellurous Acid.

TeO<sub>3</sub> = Telluric ".

Tellurous Acid.

A crystalline, white solid - formed by the combustion of metallic Te in Oxygen or Air. Insoluble in H<sub>2</sub>O. Soluble in HCl, from which it can be precipitated black (Te) by SO<sub>2</sub> + other reducing agents.



Salts of  $\text{FeO}_2$  are precipitated by H.S. - brownish; a Sulphur Acid - Soluble in H.S.

Upon Coal it is reducible to Metallic Fe;

Reac-  
tions.

By  $\text{SnCl}_2$ ,  $\text{Cu}_2\text{Cl}_2$  - it is precipitated Black - a distinction from Se.

By  $\text{SO}_2$  likewise black - the action is the same.

$\text{FeO}_3$

$\text{FeO}_3$

Prepar-  
ation.

Obtained just as  $\text{SeO}_3$  - by Oxidation of  $\text{FeO}_2$  salts by  $\text{NaOClO}$  - Precipitate the salt by  $\text{BaCl}_2$  & then get rid of the  $\text{BaO}$  by  $\text{PO}_3$  - which leaves us a watery solution of  $\text{FeO}_3$  - crystallizes in large Crystals. Heated it loses its  $\text{HO}$  & is converted to an anhydrid. Forms isomorphous salts with

492

$\text{SO}_3$ . By H. or C. the acid  
can be reduced to  $\text{FeO}_2$  &  
this in turn to Fe.

In all its compounds Fe  
may easily be recognized -  
by its behavior in the lamp.

If we bring a particle - Test.  
upon asbestos - into the Carbon

flame. (the luminous part)



& held (as with Se) directly  
& close above a dried surface  
of cold porcelain - the same

will be thickly coated with a  
black deposit of metallic Fe -

which will show the various  
reactions with reagents. viz.

Solubility with red color in  $\text{SO}_3$   
the brown color when converted  
into  $\text{FeS}_2$  & the solubility of  
this Sulphide in  $\text{NH}_4\text{SO}_4$  &c.

The separation of S. Se & Fe  
when together is as follows —

Oxidize the three substances  
 Separ. S, As. & Fe, by means of  
 strong Aqua Regia. There will be  
 of S - formed  $\rightarrow$   $SO_3$ .  $AsO_2$  &  $FeO_2$  -  
 As & Fe the two latter may be separa-  
 ted from  $SO_3$  by precipitation  
 by HCl. (forming  $FeS_2$  &  $AsS_2$ ) while  
 $SO_3$  is unaffected, & may be  
 determined by BaCl.

The Sulphides can now be  
 weighed together; - ~~the amt~~  
~~of metallic Fe & As determined~~  
 the both converted into Oxides -  
 reduced by  $Cu_2Cl$ , - & the metals  
 dissolved in  $SO_3$  (conc) - upon

applying heat, the following  
 takes place  $2SO_3 + Fe = 2SO_2 + FeO_2$  -

$FeO_2$  can be drawn out by HCl,  
 & by diluting with H<sub>2</sub>O metallic  
 As - is left behind which  
 can be weighed - & the amt of  
 the  $FeS_2$  determined from it.



The next group comprises

Nitrogen

Phosphorous

Arsenic

Antimony.

General  
Properties of  
the Group

General Characterist.

They all form with ~~all~~  
Oxygen two acids having  
the general *zusammensetzung*  
expressed by the nitrogen Compds  
 $\text{NO}_3 + \text{NO}_3^-$ ; + of forming with  
H, a compound expressed  
in the Nitrogen Compound  
 $\text{NH}_3 \rightarrow$

Nitrogen.

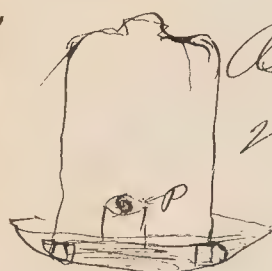
Vorkommen. Free in Nature  
Forms the greatest part of  
the Atmosphere + indeed 8 g/100 l-  
by volume. Exists likewise  
in the form of  $\text{NH}_3 + \text{NH}_4\text{OCCO}_2$   
In Organic nature largely spread

Forms a part of the constitution of all organisms.

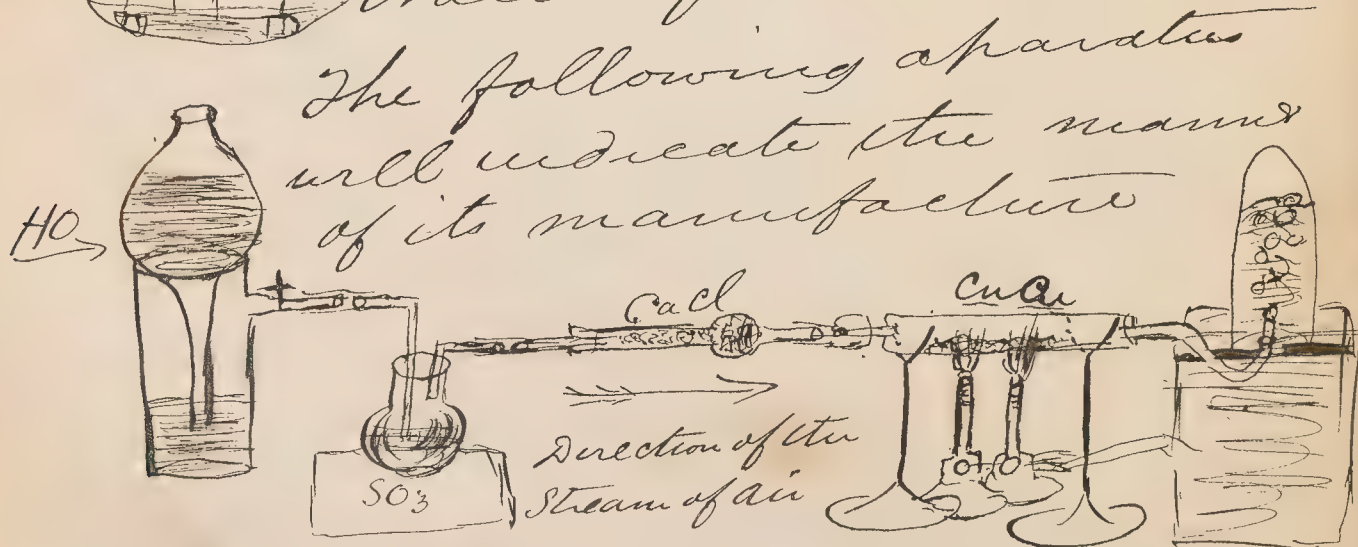
But we obtain it not from Organisms &c. but from the atmosphere, by simply removing the Oxygen - by Combustion - with some substance which forms an insoluble product of combustion - as Phosphorous.

Exp

Manufacture



As thus formed it is never pure but contains traces of  $PO_5$  &c &c.



where the object is to obtain the pure gas. It may be caught above  $H_2O$ .

## Properties.

It is a colorless - transparent.  
tastless - odorless gas - unchange-

able by light, heat, or electricity

Is incompressible - by pressure  
& cold - It is characterized

by its exquisite indifference  
to all chemical reagents.

Can only be indirectly nega-  
ted - with the most substance here  
with which it combines - 3. B. propts

With  $O_2$ , <sup>(it can comb. directly)</sup> at the highest temp.: Ex.

& at lower temps it is decom-  
posed. (By Electrical stream like  
the production of Ozone).

Likewise with C. it combines  
~~with~~ directly - at the greatest

$\left. \begin{array}{l} KO \\ CO \\ CCO \\ N \end{array} \right\} \begin{array}{l} CO \\ KC_2N \end{array}$ 
 temperature  
 which we  
 are able to  
 bring about, (on blast furnace)



Proper - Sp. gravity, 0.971311. (air = 1)  
 diss → Absorp. Calc - by H<sub>2</sub>O at 0° = 0.02035

By the decomposition of  
 Organisms, the Hydrogen  
 Compd is formed. NH<sub>3</sub>..

Nitrogen + Hydrogen.

NH<sub>3</sub>

NH<sub>3</sub> = Ammonia.

If we hang a cloth moist-  
 ened with HCl in the air -  
 after a time - some of the  
 gas will be ~~from~~ absorbed  
 in the cloth & NH<sub>4</sub>Cl formed  
 which can be drawn out  
 by H<sub>2</sub>O.

In ac-  
 tive

Volcanoes.

In active volcanoes the same  
 Comp'd, (NH<sub>4</sub>Cl) is formed by  
 the action of free HCl, formed  
 in eruptions & HCl compounds -  
 upon organic - mainly vege-  
 table matter - (Cultivated land) -  
 in the neighborhood of the  
 Eruption.

As before remarked - by the decomposition of Organic matter + Excrement - so, in many places it is manufactured - (By the distillation of Horn + Haaps - &c &c).

By distillation of Stone Coal - Some  $\text{NH}_4\text{O CO}_2$  - from which  $\text{NH}_3$  is obtained by treating with  $\text{CaO}$ ,  $\text{NaO}$  or  $\text{KO}$ , Ex

$$\text{NH}_4\text{O CO}_2 + \text{CaO} = \text{CaO CO}_2 + \text{NH}_3 + \text{H}_2\text{O}$$

The gas immensely soluble in  $\text{H}_2\text{O}$  - hence it must be collected over  $\text{H}_2\text{O}$  or by displacement <sup>downward</sup> of air - A colorless - transp. gas - with a peculiar penetrating odor - is condensible at a high pressure to a colorless liquid. Specifically lighter than air. Unlike the other

Compounds of Elements  
with Hydrogen, which  
we have observed - this comp-  
ound instead of being an  
Acid - is a strong base &  
has a strong alkaline -  
reaction, & is generally clas-  
sed with the alkaline met-  
als  $K + Na, \text{etc.}$

$NH_3$   
a  
Base

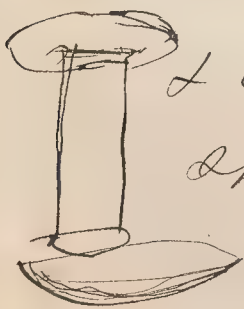
Brought into contact with  
 $HCl$ ,  $NH_3$  unites with it  
& forms an intensely white  
& thick, solid substance -  
the  $NH_4Cl$  of which we  
have already spoken.

Exp

Show its strongly alkaline  
character upon test paper.

Ex

sp. gr  
0.589.  
(air = 1)



& at the same time its  
specific gravity was  
one experiment.



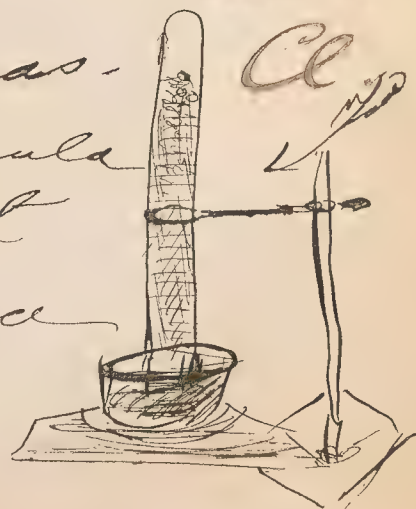
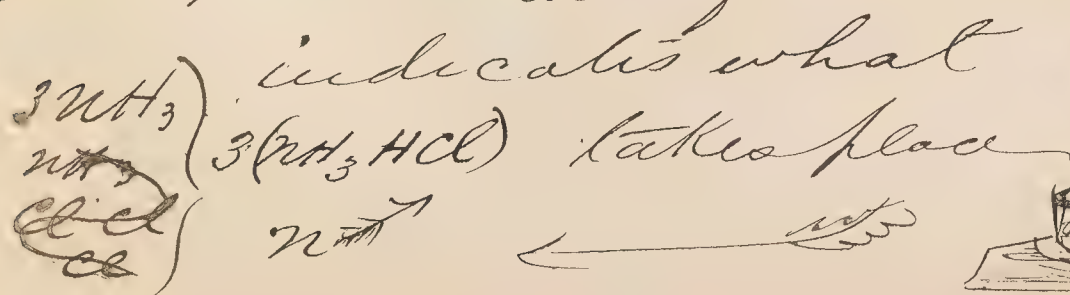
500

Lecture 54<sup>th</sup>  
Ammonia.

Decomposed at very high temp-  
eratures by O. If pure plunge  
(burning) a taper into a jar of  $\text{NH}_3$  - Exp  
at the point of contact of the  
gas with the flame will be  
seen the yellow light which  
N gives when made luminous.

If  $\text{NH}_3$  is previously mixed with  
O. a slight explosion  
occurs on nearing a burn- Exp  
ing body. or, the gas is con-  
sumed - to  $3\text{H}_2\text{O}$  + a trace per-  
haps of  $\text{NO}_2$  - into the yellow  
appearance of the N. gas.

If to a solution of  $\text{NH}_3$  in Exp  
 $\text{H}_2\text{O}$ , Cl. water is given - with  
a rapid evolution of gas. Cl  
takes place the formula



Electrical  
Decomp.  
of  $\text{NH}_3$

Ex

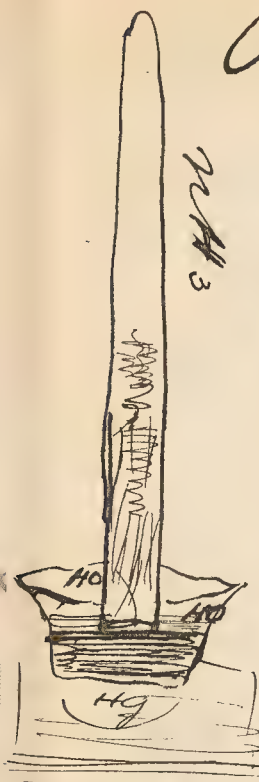
By exposing  $\text{NH}_3$  to a high temperature (namely - by - the Electrical stream) it is separated into its constituents. We can by this means, carry out the analysis of the gas. When the decomposition is complete the volume of the gas will be doubled.

The result of the analysis will give up the formulae



By 6 or 7 atmospheres it can be condensed. We make use of this property to form ice. The  $\text{NH}_4\text{O}$  is first distilled & condensed in a cold-vessel, then reversed - & the vessel of thin liquid  $\text{NH}_4\text{O}$  - placed in water - the other likewise cooled - the  $\text{NH}_4\text{O}$  removed from pressure becomes fumes produced Cold &c.

Ex  
Media  
Waria  
Coun-  
tries



A tube of  $\text{NH}_3$  above Exp  
 $\text{Hg} + \text{H}_2\text{O}$  if raised above  
 the surface of the  $\text{Hg}$ . Absorption  
 will be almost instantaneous of  $\text{NH}_3$  by  
 constantly filled with  $\text{H}_2\text{O}$ .  $\text{H}_2\text{O}$

The purer the gas the  
 more rapid the absorption.  
 $\text{H}_2\text{O}$  absorbs 1000 times its  
 volume of the gas. By heating  
 the gas can be entirely driven  
 out - for it absorbs entirely the  
 cause of absorption. We always  
 use the watery solution of  
 $\text{NH}_3$  in  $\text{H}_2\text{O}$  in producing  
~~reagent~~ reactions - for it is  
 far more energetic in its action  
 than the gas - being so concen-  
 trated - (1000 pts gas - to 1 pt  $\text{H}_2\text{O}$ )

$\text{NH}_3 + \text{Cl}$  - (in fact one upon the  
 the other) - combine with  
 the evolution of light -  
 (requires Caution) - the reac-  
 tion is given on the former page.



Cl &  $\text{NH}_3$



Beha- If we bring acids into con-  
 vior of tact with  $\text{NH}_3$  the following.  
 $\text{NH}_3$  is the result.

with  
Acids With Hydrogen acids, the  
 following results

H. acids  $\text{NH}_3 + \text{HCl} = \text{NH}_3, \text{HCl},$   
 can be called a - Hydro-chlo-  
 rate of Ammonia,

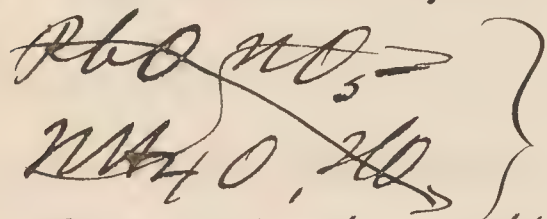
with (with  $\text{KCl}$  isomorphous)  
Oxygen With Oxygen acids the be-  
Acids havior of  $\text{NH}_3$  is peculiar.  
 The gas always takes up  
 an atom of Water - which  
 enters into the composition  
 of the comp'd - (not Crystal H<sub>2</sub>O)  
 & which cannot be separated  
 without destroying the salt,  
 & the  $\text{NH}_3, \text{H}_2\text{O}$ , thus formed  
 unites with the acid - thus -



In its behavior however this  
 salt <sup>is</sup> ~~and~~ analogous to the  
 correspond. salt  $\rightarrow \text{KO}, \text{SO}_3$  (anhyd.)

These salts (when they are of vol-  
 atile acid with  $\text{NH}_3$ ) are com- Ex  
 pletely volatile - + upon e- Volatility  
 vaporation leave no resi- of  $\text{NH}_3$   
 due behind - If the acid is Salts  
 Non-volatile -  $\text{NH}_3$  evaporates -  
 + the acid remains behind - (note  
 A good way to obtain free non volatile  
acids - by Preparing the  $\text{NH}_3$  Salt)  
 Like  $\text{K}_2\text{O}$  &  $\text{Rb}_2\text{O}$  + have it forms  $\text{NH}_4\text{Cl}$  +  
 with  $\text{PtCl}_2$  +  $\text{HCl}$  - a comes -  $\text{PtCl}_2$   
 forming double chloride -  
 of ammonia + Platinum  
 $\text{NH}_4\text{HCl} + \text{PtCl}_2$  - which  
 in its properties is anal-  
 ogous to the other salts  
 above mentioned, In all  
 respects it behaves as a  
 strong base, + its salts, are  
 neutralized - when 1 Atom of  
 Acid for 1 of  $\text{NH}_3$  is present.

To show the power of the  
 $\text{NH}_4\text{O}$  as a base - the follow-  
 ing Experiment -



So with  $\text{Fe}_2\text{O}_3$  salts

" "  $\text{CuO}$  Salts &c,

There is another compound

The of N with  $\text{HCl}$ , which in  
 Example - its behaviour - is so remon-  
 tion of Kalle - that it cannot be  
 the Recn. overlooked - + which gives  
 leads us a clue to the singular  
 of  $\text{NH}_3$  behavior of  $\text{NH}_3$ . That  
Compound is expressed by

$\text{NH}_4$  the formula -  $\text{NH}_4$  -

Man-  $\text{NH}_3 \cdot \text{HCl}$  }  $\text{NaCl}$   
 ufactum  $\text{Na Hg}$  }  $(\text{NH}_4, \text{Hg})$ .

If we ~~form~~ put together  
the  $\text{Hg} + \text{Na}$  - we obtain an alloy  
 of these two metals.





If upon this amalgam we Ex  
 pose  $\text{NH}_4\text{Cl}$  - a singu-  
 lar phenomenon will be  
 noticed: viz the mass of the  
 $\text{Hg}$  increases immensely -  
 & from a single drop we  
 will have formed - a huge  
 quantity - of another substance -  
 Which when analyzed shows  
 that it is a combination Analysis  
 of  $\text{Hg}$  + of a compd -  $\text{NH}_4$  :  
 As the latter is decomposed with  
 Ease - it must immediately  
 be brought beneath a eudiom-  
 eter & so analyzed - it then  
 falls apart into  $\text{NH}_3 + \text{H} + \text{Hg}$  -  
 This  $\text{NH}_4$  - like a metal - forms  
 then an alloy with  $\text{Hg}$  just Deduc-  
 as the Na did - it, in fact tions from  
 supplies its place - it (the this  $\text{NH}_4$   
 alloy - possesses the peculiar

This body exists in the radical having the properties of a metal, + playing Salts that role. But: this singular comp'd explains easily + readily the behavior of  $\text{NH}_3$ .

when entering into Combination - See - ! -

$\text{NH}_3$   $\text{HCl}$  - We suppose that this  $\text{H}$ . of the  $\text{HCl}$  goes to the  $\text{NH}_3$  to form this metal ( $\text{NH}_4$ ) which as a simple Element then unites with  $\text{Cl}$  to form a haloid -

$(\text{NH}_4)\text{Cl}$  - analogous to  $\text{KCl}$ , with the oxygen salts of  $\text{NH}_3$  the explanation is still as satisfactory for - we have only to suppose the following.

We know that it is only the  
 Oxides of metals that combine  
 with Oxygen acids. thus

KO SO<sub>3</sub> to form salts. &

we have seen that in the  
 formation of a neutral oxy- Expla-  
 salt  $\text{NH}_3$  takes up always nation  
 an atom of  $\text{HO}$ , which of  
 identifies itself with the na-  $\text{NH}_3$   
 ture of the salt. We have seen,  
 only to suppose that as before  
 the  $\text{NH}_3$  in contact with  $\text{HO}$ ,  
 $\text{SO}_3$  for example, takes up an  
 atom of  $\text{H}$  to form the metal  
 $\text{NH}_4$  - & then this metal forms  
 an oxide  $(\text{NH}_4)\text{O}$ , with the  
 freed  $\text{O}$  atom - & that then this  
 metallic Oxide (like any other  
 $\text{KO}$  or  $\text{NaO}$  or  $\text{CaO}$  &c) forms with  
 the  $\text{SO}_3$  a salt.

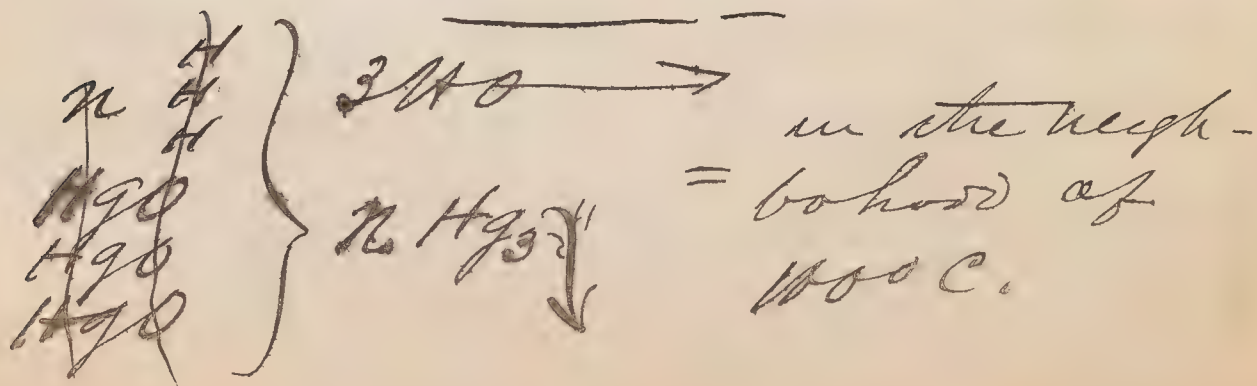
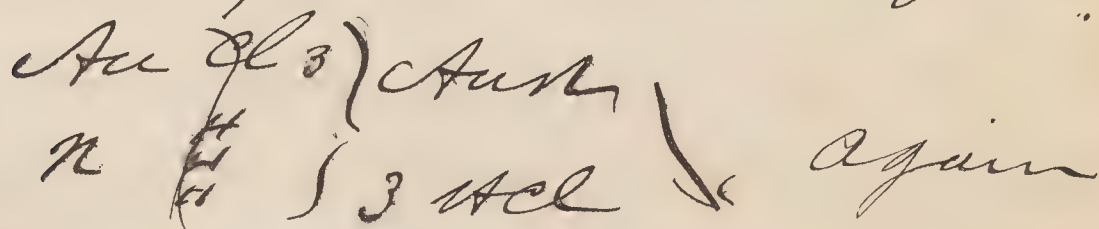


Lecture 53<sup>th</sup>

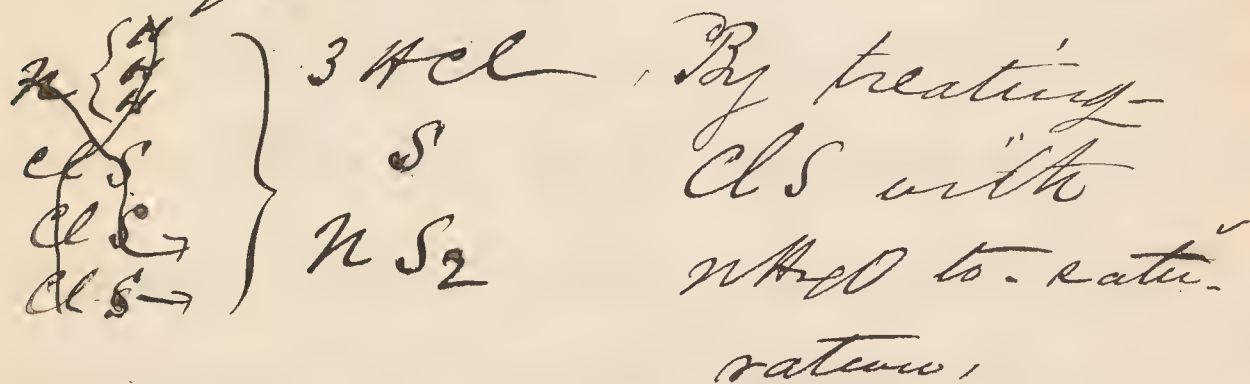
By a decomposition of  $\text{NH}_4\text{Cl}$  through the battery - at the "Restat" position pole Cl - + at the "tipping" negative do.  $\text{NH}_3$  is given off.

A confirmation of the Theory of the Ammonia Salts -

By bringing  $\text{NH}_4\text{O}$  into Contact with Metallic Oxide. There is not, as with the other H Compds we have considered, a corresponding Nitride formed - but another reaction takes place - + only - except - tionally is the Nitride formed.



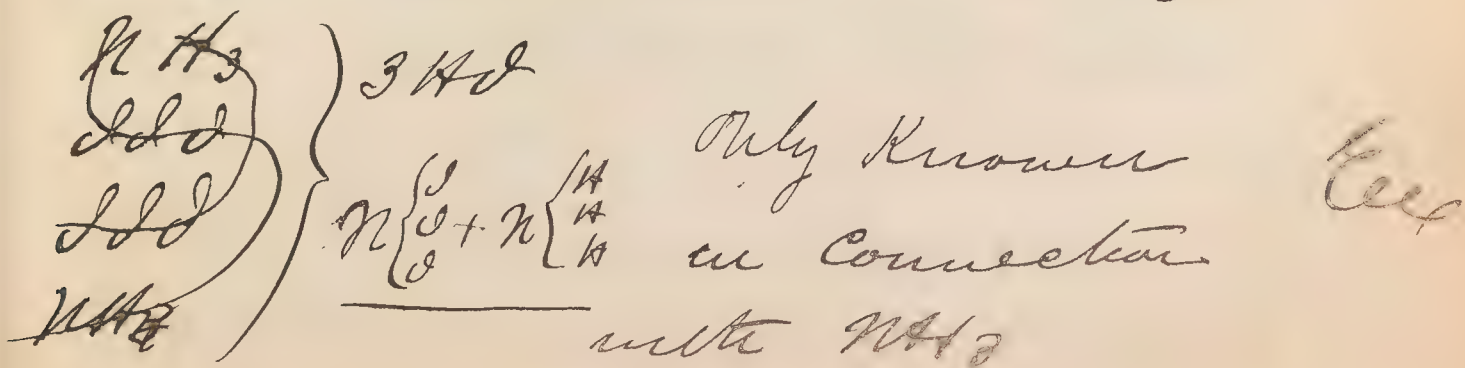
The same occurs with  $\text{CuO}$ , & the corresponding nitride is generally formed, but not always - see



We are enabled to bring about quite a number of reactions having this general properties & the universal of all properties of being fearfully explosive. Compds.

$\text{NH}_3 + \text{N}_2\text{O}_3$  have been most accurately researched.

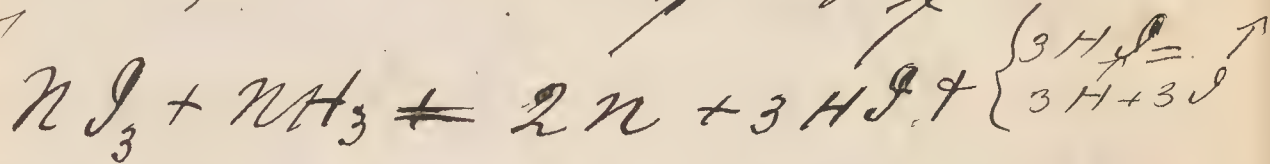
$\text{N}_2\text{O}_3$  is formed by allowing  $\text{O}$  to act upon  $\text{NH}_4\text{O}$ :- they:-



N I<sub>3</sub>

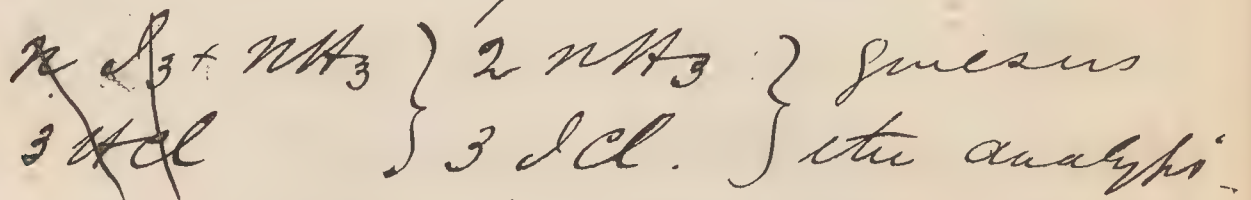
Formed by treating finely powdered I with concentrated NH<sub>4</sub>O, the Precip. is brought upon a filter & when thoroughly dried - can be exploded by a touch of a feather -

Exp



Thus inconceivable gases are formed. hence the power of the explosion. It cannot be analyzed directly, on acct of this terrific explosibility.

By treating it with HCl. it is decomposed into ICl.



Just as I - so Cl behaves toward N - forming that most explosive of all compounds known to the Chemist - & called Ter. Chloride of Nitrogen

NCl<sub>3</sub>





Composition is not exactly known. It may be united with an atom of  $nH_3$  just as  $nO_2 + nH_3$   $nCl_3$  but owing to its fearfully explosive nature cannot be analyzed.

In 1811 by Dulong of Paris who prepared a considerable quantity of it for analysis, not knowing its nature. It exploded & cost the unfortunate experimenter 4 fingers - his hearing & the sight of one eye.

If this substance is touched with certain substances it explodes with terrific violence Turpentine &c. the greatest caution must be used - & the quantity experimented with must be very small, to avoid accidents.

Gaslicht-  
Lichter

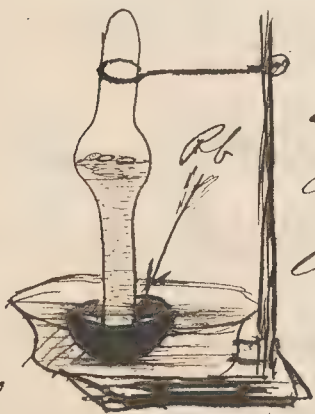
Prop-  
erties

Es

By its decomposition it  
is resolved into the same  
compounds as  $N_2O_5$ , viz.  $N$   
 $N + 3HCl \rightarrow$

Best prepared by leading  
into a concentrated  
solution of  $NH_4Cl$  - in  
a tube, of the form in  
the figure, a slow  
stream of chlorine,  
the tube, after the fluid ~~has~~<sup>then</sup>  
assumed a yellow color.

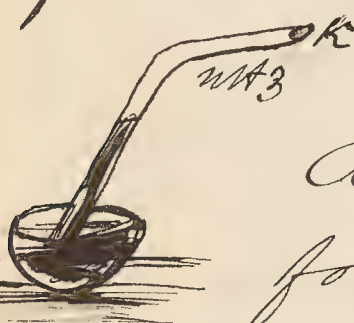
It is then placed over a vessel  
of lead - (which is only deuced  
by an explosion), soon, oily  
drops begin to accumulate  
on the surface, & fall to  
the bottom in the leaden  
vessel, if a small drop -  
is then obtained beneath the  
 $N_2O$ , the apparatus may be rem-  
oved from the Pb vessel - &  
the explosion carried on.



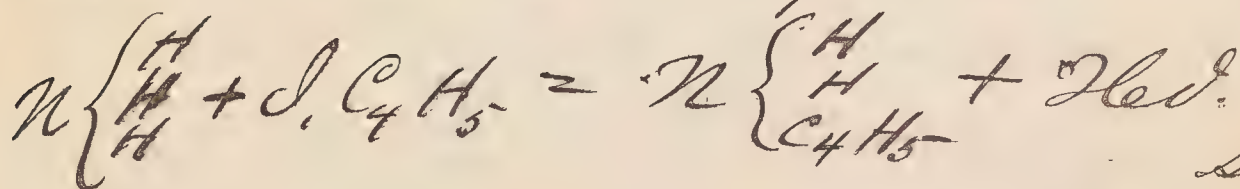
Ex

In a  
Lead  
Vessel.

Just as the three atoms of H, are replaced by Cl + I etc. so can also 1 or two atoms of H be replaced. ↑ E.g.



An a line green body formed as the reaction indicates - Bodies in which 1 atom of H is replaced by foreign substances are called - Amids. Again



Substi-  
of upon this substance we <sup>tution</sup> of H  
continue to let Ethyl <sup>(iodide)</sup> ~~work~~ <sup>K</sup> by C<sub>4</sub>H<sub>5</sub>  
we can ~~for~~ substitute another  
atom of C<sub>4</sub>H<sub>5</sub> for H. + by still  
further action all the H can  
be represented by C<sub>4</sub>H<sub>5</sub> -

Bi + tri - Ethyl-ammonium





Lecture 5<sup>th</sup>

Nitrogen + Oxygen.

$\text{HO NO}_5$  = Nitric acid.

$\text{NO}_4$  = Hypo nitric acid.

$\text{NO}_3$  = nitrous acid.

$\text{NO}_2$  = Nitric Oxide.

$\text{NO}$  = Nitrous Oxide.

The first three are acids  
as their names indicate  
the last two - neutral bodies.

 $\text{NO}_3\text{HO}$ 

Nitric  
Acid.

Manufac  
ture

Formed by direct union  
of  $\text{N} + \text{O}$ , but only a small  
quantity. Again By passing  
an Electrical stream through  
moist air. Or by mixing  
 $\text{NH}_3$  with  $\text{O}$  & exploding  
but in all these methods  
we only small quantities  
& practically they are of no  
avail.

576

If we bring into a flask, Exp  
of air some  $\text{NH}_3$  & bring  $\text{NH}_4\text{Cl}$   
into it a platinum draught air  
(previously glowed) - it con- sp.  
tinues to glow forth - the reaction  
 $\text{NH}_3 + \text{O}_2 = 3\text{H}_2\text{O} + \text{NO}_2$ . No prac-  
tical use has yet been made  
of it. In the neighborhood of a  
decaying animal excre - Organic  
ment - (urine &c) - there are nature  
always found - salts of  $\text{NO}_5$ . How  
& great use is now made Manufact.  
of this method of procuring  
partic.  $\text{KONO}_2$  (for various  
uses in the arts. man. of gunpowder)  
First  $\text{NH}_3$  is formed - which by  
contact with the organic mat-  
ter forms  $\text{NO}_5$  - which in  
presence of  $\text{KO CO}_2$  -  $\text{NaOCO}_2$  -  $\text{CaO}$  -  
 $\text{CO}_2$  &c &c forms the corres-  
ponding Nitrates. In manu-  
facturing it, the Organic matter

$KONO_5$  577 is heaped in piles alternating  
with wood ashes. Potash &c  
Efflorescence & exposed intrinsically to the atmosphere  
here for years. Then  $KONO_5$   
is drawn out with  $H_2O$  -  
 $KO CO_2$  given to it to precipitate  
 $CaO NO_3$  +  $MgO NO_3$ , & then crystallized

Rover as efflorescence from the earth,  
of Paris the formation being the same  
The mouldings & mortar of Paris  
houses is made of gypsum, in  
which is  $CaO CO_2$  - the action of  
 $NH_3$  in the atmosphere, after  
long years produces a decom-  
position of the latter - forming  
 $-CaON_5-$

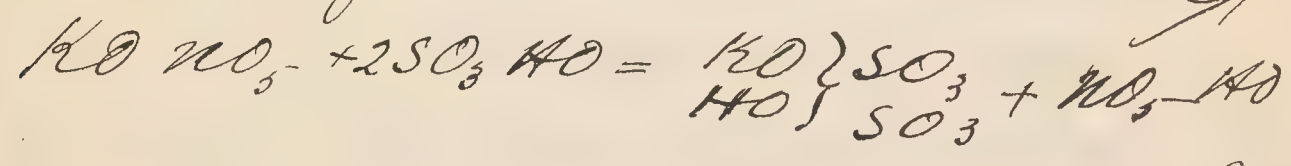
In Chile - Atakama - a region  
where it never rains - there

Chile exists an immense bed  
of  $NaON_5$  - which is now  
being transported in im-  
mense quantities to Europe  
& N. America for various  
uses in the arts.



(Whether by these slow decomp.  
a direct union of  $N + O$  to  
 $NO_5$  is formed is not yet as-  
certained perhaps small  
quantities of ozone are formed  
& with this the  $N$ . comb. directly?)

From  $KO NO_5$  we can man-  
ufacture the  $NO_5$  by the Exp  
action of a stronger acid.



We use 2 atoms of  $SO_3$  bec. Manufacture  
and we can free the  $NO_5$  more  
easily, when  $KOHO, 2SO_3$  is formed here Exp  
than when  $KOSO_3$  is formed -  
for then the  $NO_5$  is only freed  
from its comb. at a temper-  
ature when it is decomposed.  
It forms then a colorless -  
fluid, which gives out fumes  
in the air. of a peculiar

Easily decomposable into the lower Oxides of Nitrogen. The action of light - & of the gentlest heat is suffe-

Prop. of heat to cause it to give up part of its Oxygen, while HONO  $\text{NO}_2$  -  $\text{NO}_3$  +  $\text{NO}_4$  are formed.

It is a most powerful oxidizing agent - it can easily give up one, two - three & even four atoms of its ~~oxidation~~ oxygen.

Ex At ordinary temp's. Sn is oxidized. So with Cu &c &c Most metals & metalloids are oxidized energetically by this substance - Au & Pt metals form almost the only exception to the rule.

Ex With many organic substances ~~NO~~ produces such intensely vigorous oxidation

as to cause the production <sup>of</sup> Turpentine  
 of light & explosion - With Oil &  
 turpentine Oil for example: -  $\text{NO}_2 + \text{SO}_2$   
 the most energetic action is  
 produced. The two compounds different  
 of  $\text{NO}_2 + \text{H}_2\text{O}$  -  $\text{NO}_2 + \text{H}_2\text{O} + \text{NO}_2 + \text{H}_2\text{O}$  Action  
 +  $3\text{H}_2\text{O}$  act entirely different of -  
 upon certain metals,  $3\text{H}_2\text{O}, \text{HONO}_2$   
 Ordinary  $3\text{HCl} + \text{HONO}_2$  will acidify +  $\text{HONO}_2$   
 Fe, at ordinary temp's, with gas in  
 evolution.  $\text{HCl}, \text{NO}_2$  will not. If - Oxidation  
 Fe after being placed in dilute  $\text{NO}_2$  Exp  
 is placed a few minutes in Conc, with Fe  
 $\text{NO}_2$  - then again placed in dilute  $\text{NO}_2$   
 $\text{NO}_2$  - the latter loses the property  
 of dissolving it & it remains un-  
 dissolved & unattached. If now it  
be touched with a piece of Fe, not  
previously placed in  $\text{HONO}_2$  it will  
immediately be attacked by the dilute  $\text{NO}_2$ .  
 Ordinary Fe possesses the property



Exp of reducing the salts of Cu. + taking  
~~its~~ place in the Compd.  $\text{CuSO}_4 + \text{Fe} =$

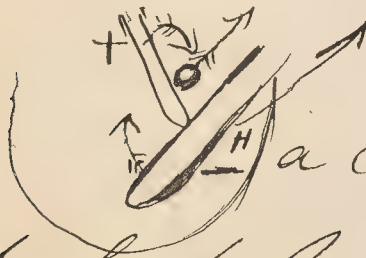
Exp plan.  $\text{FeSO}_4 + \text{Cu}$ . If, however, the Fe  
 atom be previously placed in concen-  
 of the trated  $\text{NO}_2$ , it loses this prop-  
 Phenomenon-erty of reducing Cu. If, now  
enough after placing it, in  $\text{NO}_2$ -concent.  
 it be dipped into  $\text{CuSO}_4$  solution,  
 it will not affect the solution  
 the slightest. but upon remov-  
ing it from the solution - +  
touching it with a piece of  
Iron not previously placed

Exp  
in conc.  $\text{NO}_2$  -, it instantly  
converts itself with a coating  
of  $\text{Cu}$ . The passive Iron -  
 as it is called, is subjected up-  
 on its surface, to a change  
 which renders it in its chem-  
 ical Character, analogous to  
Pt-au + c. When brought

~~into~~ with Ordinary Fe. into con-  
 nection ~~as~~ with a galvanic cur- Eco  
 rent, it behaves <sup>negative</sup> ~~positive~~ to the Planch.  
 Ordinary Fe. which acts <sup>positively</sup> ~~negatively~~.

Singularly enough - Hydrogen  
 gas - has the property of destroy-  
 ing this allotropic surface

Condition of the Fe, & this  
 is the explanation. of the fact  
 that when touched - with un-  
 changed Fe, the altered Fe. at  
 once is dissolved - or coats itself  
 with Cu, For when touched

 with ordinary Fe.  
 a current is established,  
~~of which~~ from the positive (ordinary)  
 Fe to the neg. (changed) Fe.

Hydrogen is given off at the  
 surface of the allotropic Fe -  
 & oxygen at the surface of the  
 Ord. Fe. But we have al-

ready mentioned, that Zn possessed the property of destroying this allotropic condition - When, therefore the two kinds of Fe come together a current is established, & the H generated on the surface of the allotropic Fe - instantly reconverts it to Ordinary Fe, which then recovers its capacity of being dissolved in dilute  $\text{HNO}_3$ , & of Reducing  $\text{Cu}$ ,  $\text{HCl}$ , &c.

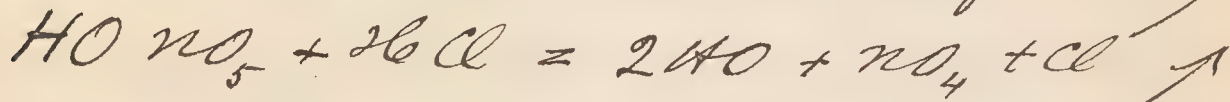
The same Phenomenon has been observed with Sn & perhaps will hold good with many other metals when the necessary experiments are made.



Lecture 5<sup>th</sup>

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$\text{NO}_2$  possesses the property of decomposing  $\text{HCl}$ ,  $\text{HBr}$  &  $\text{HI}$  &c. setting  $\text{Cl}$  or  $\text{Br}$  or  $\text{I}$  free.  $\nearrow$



So the decomposition may be such as to form even  $\text{NO}_2$  &  $\text{NO}$ . We use this method

when we wish to form a fluid containing free chlorine

This mixture was known to the alchemists even, as having

the power of dissolving 'Aqua  
gold' - & called by them 'Aqua Regia  
Regia' - Royal Water. Ex

By gentle distillation this fluid  
of different Boiling Points  
go over - viz  $n\{\text{Cl}^{\text{O}_2}\} + n\{\text{Cl}_2^{\text{O}_2}\}$   
Can not however be ob-  
tained pure

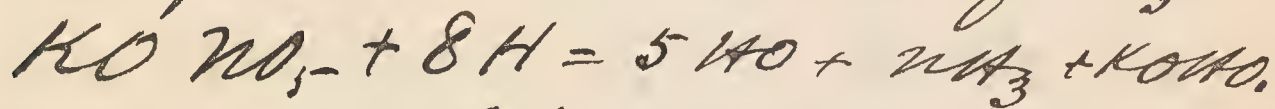
Tests All the salts of  $\text{NO}_3^-$  are soluble in Water - Hence we can have no precipitates -

$\text{NO}_3^-$  He must first show that the acid is a strong oxidizing agent -

Eg  $\text{NO}_3^- \text{ Salt} + \text{SO}_3 + \text{H}_2\text{O} + \text{Indigo}$  -  
but, as yet we have no distinct test, &

FeO SO<sub>3</sub> Every general & good test for nitrates is, to convert the nitrate solution with some concentrated  $\text{SO}_3$ , in order to free the acid. & then to add a drop of a solution of FeO.  $\text{SO}_3$  & the  $\text{NO}_3^-$  in being driven out by gentle heating, is decomposed into the lower Oxides -  $\text{NO}_4, \text{NO}_3 + \text{NO}_2$  &c, the latter possesses the peculiarity of discoloring in FeO SO<sub>3</sub> with a black color, & this is the test

Nitric acid in an alkaline fluid is converted by H into  $\text{NH}_3$ . & by titrating this with ~~with~~  $\text{HCl}$  of a determinate strength we can reckon from the  $\text{NH}_3$  formed the amt of  $\text{NO}_5$



Thrown upon burning coal the nitrates possess the property of giving Exp up their O freely & they puff up.

### $\text{NO}_2$

Manufactured → From  $\text{NO}_5\text{HO}$  by treating ditto with Cu.  $\text{NO}_2$

$$4\text{HO NO}_5 + 3\text{Cu} = 3\text{CuO NO}_5 + \text{NO}_2$$

The gas is a colorless & trans. Exp parent gas - neither acid, nor base - perfectly indifferent. Incombible - & a strong affinity for Oxygen, &



a jar of it be opened to the air it takes up yet 2 more Ex atoms of O - forming  $\text{NO}_2$  which gives an acid reaction. If O is lead into it it beneath the trough - Ex it takes on a red color & is absorbed in  $\text{H}_2\text{O}$ .

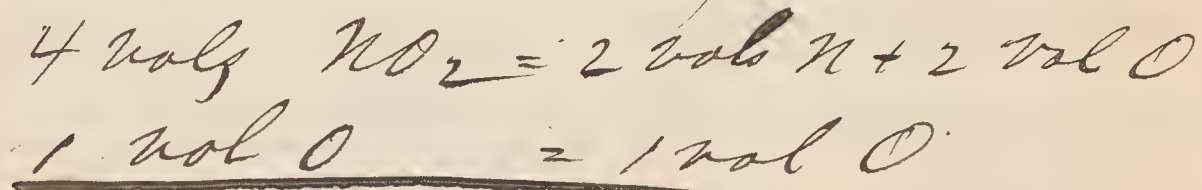
Ex  $\text{FeO SO}_3$  is a good solvent of  $\text{NO}_2$  - with a black color In this way we can separate  $\text{NO}_2$  from  $\text{NO}$  by: - In manufacturing  $\text{NO}_2$  from Cu - a portion of

Method of purifying  $\text{NO}$  from  $\text{NO}_2$  & vice versa  $\text{NO}$  is formed. So also with  $\text{H}_2\text{O}$   $\text{NO}_5 \rightarrow$  - to obtain the NO pure. we have only to pass the liberated gases through a solution of  $\text{FeO SO}_3$  - which retains the  $\text{NO}_2$  & allows the  $\text{NO}$  to pass over pure.

Sulphur (burning) plunged  
 into this gas ~~light~~ is extin— Eg  
 pushed. Paper - &c &c  
 Phosphorus, however, if  
 strongly heated - will burn  
 vigorously in the gas - Eg  
 the flame as when burned  
 in O. If we vaporize  
 CS<sub>2</sub> in this gas - & then Eg  
 fire gives a most intense  
 light, & the greatest chemical  
~~action~~ that can be artificially intensity  
 produced. Lead over glowing  
 Cu - it is reduced to NO  
 to N. In this way we can Analysis  
 Carry out the Analysis of  
 NO<sub>2</sub> - Of 2 vols NO<sub>2</sub> thus treated  
 1 vol N = 0.9674 remains  
 1 vol O = 1.1095 united.  
 2 vol N<sub>2</sub> = 2.0769 { gives no an  
 1 vol NO<sub>2</sub> = 1.0385 { atomic form.  
 ula = NO<sub>2</sub>

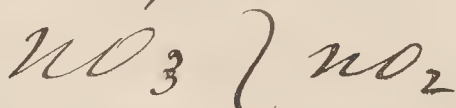
Manufac-  
ture  
+  
Proper-  
ties

By letting determinate quan-  
tities of Oxygen into Contact  
with NO<sub>2</sub> we can form  
either NO<sub>3</sub> or NO<sub>4</sub>.



2 vols NO<sub>3</sub> = 2 vols N + 3 vol O.  
(Never more than 1/4 the  
amount of O- shd be add  
to the gas vol).

Forms in solution a  
deep green fluid. Giving  
Proper- out red fumes in the air.  
ties. Cannot be distilled without  
decomposition.



With H<sub>2</sub>O it is decomposed  
Ex into 2 NO<sub>2</sub> + NO<sub>3</sub> —, this  
$$3 \text{ NO}_3 = 2 \text{ NO}_2 + \text{NO}_3$$



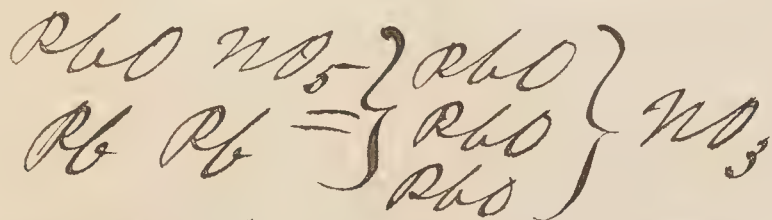
With bases it is likewise decomposed into Nitrates +  $\text{NO}_2$  is given off..

It stands upon the transition ground between Oxidizing & reducing agents - Hence, it reduces some substances & Oxidizes others

It reduces  $\text{Cr}_2\text{O}_3$  to  $\text{Cr}_2\text{O}_3$  Ex  
Oxidizes  $\text{KCl}$  to  $\text{KClO}_3$  &  $\text{KClO}_4$ .

Manufactured by heating  $\text{AgONO}_2$  - thus  
 $\text{AgONO}_2 \xrightarrow{\text{heat}} \text{AgO} + \text{NO}_2 + \text{O}_2$  Note  
 $\text{AgO} + \text{NO}_2 + \text{KCl} = \text{AgCl} + \text{KONO}_2$

Again, by heating  $\text{PbONO}_2$  with metallic Pb.



$\text{NO}_2$  possesses the singular prop. of combining with acids - ( $\text{NO}_2$ ,  $3\text{SO}_2$ ).

This substance is formed in the  $\text{SO}_3$  manufactories, and marks an important step in the operation of the formation of  $\text{SO}_3$ . It sets itself upon the sides of the apparatus in the form of a white crystalline solid, which disappears + reappears at regular intervals in the process of manufacture. A discussion of its properties will form the opening phase of the next lecture.

This is not a salt. for  $\text{NO}_3 + 3(\text{HOSO}_3)$   
 we cannot replace. either con-  
 stituent by another acid or an-  
 other base. it is formed thus  
 $\left. \begin{array}{l} \text{+ SO}_2 \\ \text{OO} \\ \text{+ NO}_2 \end{array} \right\} \text{+ SO}_3 \text{HO; NO}_3 \cdot$  the decom-  
 position +  
 recombination  
 marks the transition a man.

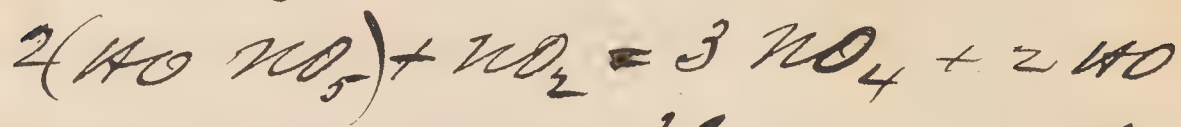
It decomposes in presence  
 of HO - to  $\text{NO}_3 + 3(\text{HOSO}_3)$ . By  
 the former is decomposed into  
 $2\text{NO}_2 + \text{NO}_5 - \text{etc etc}$ , see  
 previous lecture

### $\text{NO}_4$ -

Manufactured most easily by  
 the dry distillation of  $\text{PbONO}_5$ .  
 $\text{PbO NO}_5 = \text{PbO} + \text{NO}_4 + \text{O} \rightarrow$   
 Or. by bringing 4 vols of  
 $\text{NO}_2$  - into contact with 2 or more  
 vols of O.



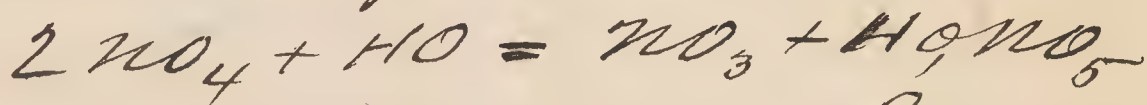
Again, by leading  $\text{NO}_2$   
in  $\text{NO}_5$  - thus



Has great

resemblance with  $\text{NO}_3$  -

Decom. It is decomposed by HeO  
position like the former.



Exp

It cooks by  $280^\circ$ .

the color of the fluid is red-  
dish brown. It acts both

Oxidizing & reducing -

It can unite with bases to  
form  $\text{NO}_4$  salts.  $\text{NO}_3$  &  $\text{NO}_5$ -  
salts are formed at the  
same time - & some  $\text{NO}_4$

Salt.

Fuming  $\rightarrow$  Fuming  $\text{NO}_5$  used in the  
 $\text{NO}_5$  laboratory for Oxidizing &c.

$\rightarrow$  is a  $\text{NO}_5 \cdot \text{HO}$ , which contains  
more or less  $\text{NO}_4$  &  $\text{NO}_3$ , hence red color

# NO

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Formed by the reduction of  $\text{NO}_2$  - (with Cu shavings + + moisture) - Again, pure - by heating,  $\text{NH}_4\text{ONO}_2$  - by simple heating



It is a colorless + transparent gas. The analyses - shows that -

$$2 \text{ vols N} = 1.944$$

$$1 \text{ vol O} = 1.104$$

$$2 \text{ vols NO} = \underline{3.048}$$

1 vol.  $773^\circ\text{C}$ . NO = 1.524 Sh. gr. NO. Proper

This gas has been condensed. has a peculiarly agreeable smell. Gas is respirable - but acts like Chloroform. It is rapidly replacing the use of Ether + Chloroform in medicine. Must, for safety - be carefully freed from  $\text{NO}_2$

When exposed it is given out mostly as N - the blood acting as its decomposer. In its general character it resembles the atmosphere.

Key → It is neither acid nor base. It is a supporter of com-  
bustion. A taper plunged  
theyll. into the gas burns with a  
low flame much brighter than  
of N is the case in air. + the  
<sup>greatest</sup>  
~~most~~ peculiarity is the pres.

Key ence, at the top of these flames  
a yellow illuminated space  
(Saun), of glowing nitro-  
gen - characteristic of  
NO<sub>2</sub>. (S. + P. show the same  
yellow color, a fine Fe wire  
burns also, but difficultly.  
Cannot form compounds  
being neither acid nor base



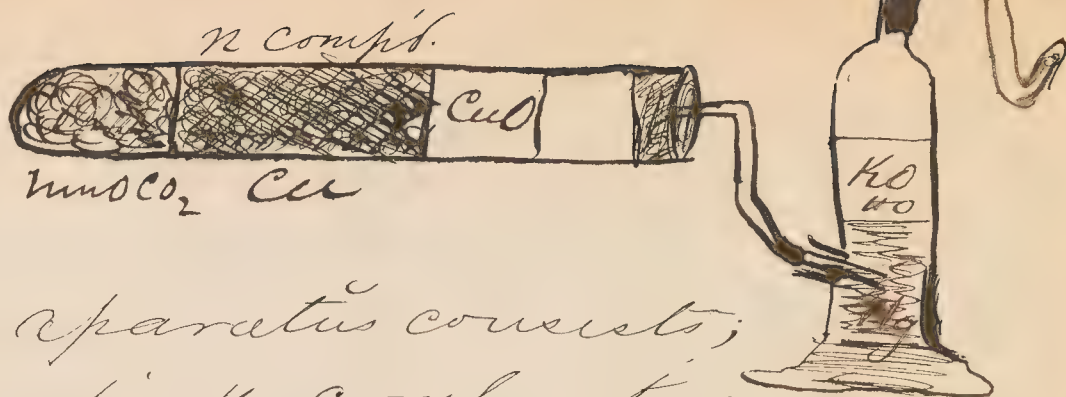
From this behavior, it naturally is this must be inquired, is this substance really a chemical Compound - or only a mixture really of  $n + O$  (like the air) in the prop. a Chem. mixture of 2 vols  $n$  to 1 of  $O$ .

If it was a mixture  $NO_2$  gas when reduced? brought into it would be colored red by the formation of  $NO_4$  from the free  $O$ , this is not formed. with  $NO$ .  
 2<sup>nd</sup> The Analogy of its volumetric Compas. with  $H_2O$ ,  $H_2Cl$ ,  $H_2O$  &c prove it a compound. 3<sup>rd</sup> when mixed with  $O$  - it is not colored red. hence no  $NO_2$  can be present in the substance. these prove it a true Chemical Compound.

General method of analysing  $N$  compounds -

Take from the acid of  $N$ . the Oxygen - by means of  $Cu$  - measure the volume of  $n$  left behind, & <sup>from</sup> the weight of the  $O$  in the  $Cu$  we can determine its volume &c.

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Analysis  
of N Comp-  
ounds



The apparatus consists;  
 1<sup>st</sup> of a thick combustion  
 tube - 2<sup>nd</sup> of a collecting jar  
 The tube is filled at the farther  
 end with  $MnCO_2$  - then comes  
 the N comp's mixed with  
 Cu clippings - then  $CuO$  - then  
 the jar having at the bottom some  
 $Hg$  & above,  $KO$  -  $MnCO_2$  is first  
 heated to drive out all the air -  
 then the tube is placed in the op-  
 ening of the jar - and the  $Cu$  &  
 N comp's - are heated -  $Cu$  oxidiz-  
 es itself at the expense of the  
 oxide of N. & the N &  $CO_2$  in  
 the tube are driven into the jar  
 $CO_2$  is absorbed by  $KO$  & the N  
 remains above. at last the  $MnCO_2$   
 $CO_2$  is heated again to drive out  
 the remnants of N - the, N then  
 passes into a gasometer - (Eudiom)-  
 by pouring  $Hg$  in at the opening -  
 & then measured.  $O$  with  $CuO$  is  
 weighed. & the analysis finished.

The N  
 Comp's can  
 be first  
 weighed in  
 a glass bulb.  
 & placed in  
 the Cu. then  
 the heat will  
 break the  
 thin glass  
 walls -  
 the O will  
 then be de-  
 termined  
 from the  
 loss.

Phosphorus.Occurrence

Widely spread in nature.  
Occurs in very small quantities in the oldest rocks.

The filtration of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  have washed out all the  $\text{PO}_5$ -Salts  $3\text{CaOPO}_5$  - from these old rocks.

It is the most necessary ingredient for the nutrition of plants + animals. the former take it from the soil, the debris of rocks - from the plants it passes into animals - + in them, is concentrated - to such an extent that here - is the place from which the chemist obtains his supply. The minerals - Apatite =  $(3(3\text{CaOPO}_5 + \text{Ca}(\text{Cl})) + \text{Phosphorit}$  a variety of the same - are those which contain most P in nature.



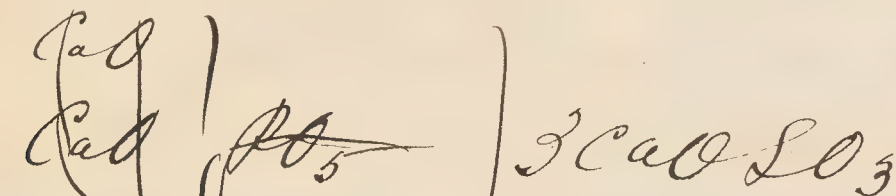
Manufacture Lecture 5<sup>th</sup>

Calcined bones are those which have been - freed by burning from their organic matter - & from these the most Phosphorous is obtained -

Coprolites of Savreais - have been found in such quantities as to make the manufacture of P Compds, from them a matter of profit.

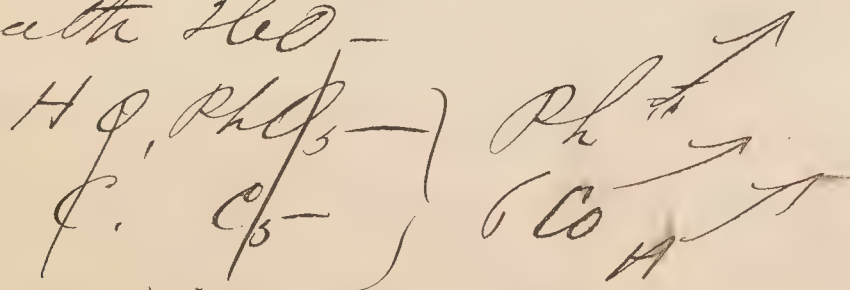
Historical Phosphorous was discovered by Brandt of Hamburg - a bankrupt merchant, who turned to alchemy to mend his broken fortunes, (See Geschichte der Chemie) - & by his discovery succeeded. He manufactured it from Urine by, glowing it after evaporation.

Manufactured exclusively from  
the Calined bones - which con-  
sist principally of  $3\text{CaOPO}_5$  -  
by treating ditto with,  $\text{SO}_3 + \text{H}_2\text{O}$



Manufac-  
ture from  
Bones

This is evaporated to dryness  
+ the anhydrous  $\text{PO}_5$  - is then  
+ reduced by Coal at a red heat,  
+ the Phosphorous distilled &  
collected into  $\text{H}_2\text{O}$  in moulds  
for the purpose. after re-melting  
beneath  $\text{H}_2\text{O}$  -



Prop-  
erties



Freshly prepared it is half transparent, of a slightly yellow color - & of a waxy lustre. Which possesses so intense an affinity for  $O$  that it must be kept beneath  $H_2O$ , maybe cut with a knife - being of waxy consistency. Sp. Gr = 1.826. Melts at  $44^\circ C$ , vaporizes at  $290^\circ C$ , Combines with  $O$  in the air when heated to  $60^\circ$

When kept at a temperature of about  $270^\circ$  for some time - it is converted into a remarkable modification. Possessing the following properties. a deep-red amorphous mass or powder - with not nearly so eager an affinity for  $O$  - oxygen that ordinary Ph has. Can be kept with impunity in the air. Sp. Gr. = 2.10 Not combustible by friction.



Phosphorous is readily dissolved in  $CS_2$  - & when it is evaporated very slowly the P is crystallized out in Regular system Exp (The Allotropic P is however not soluble in  $CS_2$ ) -

Of this solution of P in  $CS_2$  is allowed to evaporate in the air. the P which is in a finely divided condition will inflame itself, or if poured upon Paper, it will in - Exp flame the latter spontaneously.

To show the slight causes which will bring about a combustion in air - Rub a small piece of it in paper & it will break Exp out in flames. To pulverize it - it is melted in H<sub>2</sub>O (warm) & then shaken vigorously, it is finely granulated, continue shaking till P is hardened

Slow com - Even as low as  $9^{\circ}\text{C}$ . the  
 lustrous Phosph. slowly combines,  
 to  $\text{PhO}_3$  with  $\text{O}$ , to  $\text{PhO}_3$  - which  
 Comb. to combustion - maybe seen  
 $\text{PO}_5$  - in the dark. (Gone smell  
 accompanied)

Rapid  
 Combins.  
 two gives  
 mainly  
 $\text{PhO}_5$

Ph. can combine with  
 evolution of light & heat in  
 Cl. I. Br. &c.

### Allotropic Ph.

A substance much more  
 indifferent than ord. P. with  
 red color. Sp. gr. 2.10. Melts at  
 temp. above  $250^{\circ}\text{C}$ . Is insoluble  
 in the ordinary solvent  
 for Phosphorus - viz!  $\text{CS}_2$  -  
 & is not Poisonous. It

Indiff. Must be heated to above  
200  $^{\circ}\text{C}$ . before it will com-  
 bine with  $\text{O}$ . By distillation  
 of this modification we ob-  
 tain Ordinary Ph.

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In forming the various  
Compounds of P. with met-  
als the Chemist generally Matches  
uses amorphous Ph; for the  
Chemical action is not so  
violent + dangerous as with  
Ordinary Ph.

The great use of Allotro-  
pic Ph. is in the manufac-  
ture of matches - A mixture  
of melted Ph. Sulphur + Glue  
is made + the sticks thrust  
into it.

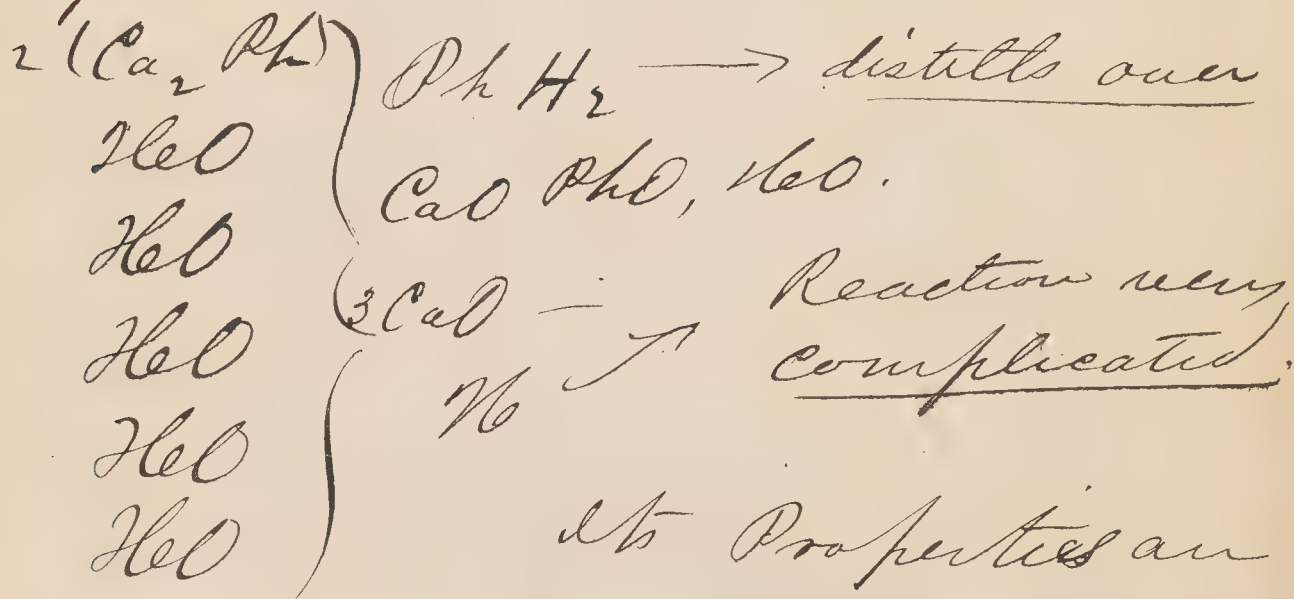
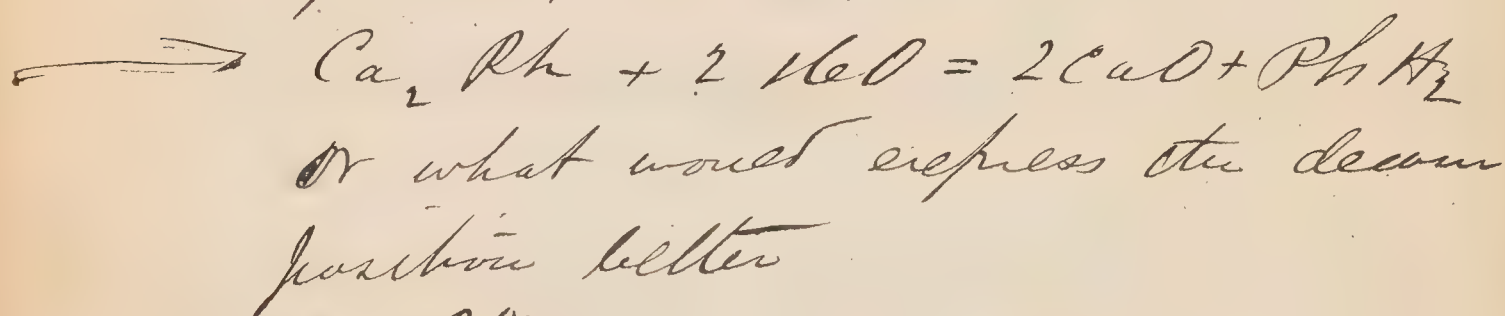
Phosphorous + Hydrogen  
 $\text{Ph}_2\text{H}_2$  = solid  
 $\text{Ph}_2\text{H}_2$  = liquid  
 $\text{Ph}_3\text{H}_3$  = gaseous. ( $\text{NH}_3$ )

The first compound is  
formed like most H Compds  
but best - by treating  $\text{Ca}_2\text{P}$   
with  $\text{HCl}$  - water left ab-  
solves.

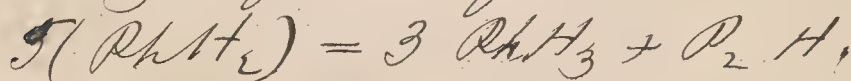


545  
 Properties a white Powder, dissoluble in  $H_2O$   
 $\sim C_4 H_6 O_2$  - Decomposable - even  
 in sunlight into  $H$  gas +  $PO_3 + P_2$   
 of no chemical importance

Ph  $H_2$  The second Compound is formed  
 by the decomposition of  $Ca_2 P$ .  
 by  $H_2O$ ; thus -:



Its Properties are  
 as follows, a very decomposable  
 fluid - insol in  $H_2O$  - decomps-  
 sing of itself into -

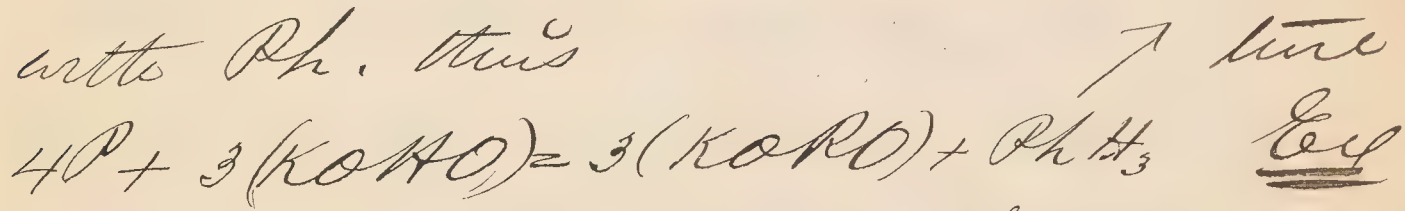


Burns with a blinding white  
 flame to  $H_2O$  + Oxides of Ph.

Ph H<sub>3</sub>.

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Formed by the decomposition  
of the Ph H<sub>2</sub> - but generally con-  
tains some Ph H<sub>2</sub> - whence  
it obtains its combustible prop-  
erties. Generally manufactured  
by heating a solution of Man-  
CaOHO, BaOHO, or KOHO in fac-  
into Ph. this



More or less PhH<sub>2</sub> is also formed  
which gives to this compound its  
self-combustibility.

By opening a jar of it to  
the air, it immediately inflames  
itself & burns - giving off fumes  
of PO<sub>5</sub> - the well known  
Exper. of manufacture &  
allowing the gas to emerge  
into the air from beneath  
H<sub>2</sub>O is here in place.

Lecture 60<sup>th</sup>

Oxygens will burn in the  $\text{PtH}_3$  - just as in  $\text{H}$ , Comp. by volume.

Comp.  $\frac{1}{2}$  vol  $\text{Ph} = 2.250$

by 3 vols  $\text{H}_2 = \underline{0.2076}$

Volume 2 vols  $\text{PtH}_3 = 2.4576$

1 vol  $\text{PtH}_3$  (or  $773^{\circ}\text{C} = 1.2288^{\circ}\text{mm}$

The volume-relationships is not that of  $\text{NH}_3$ .

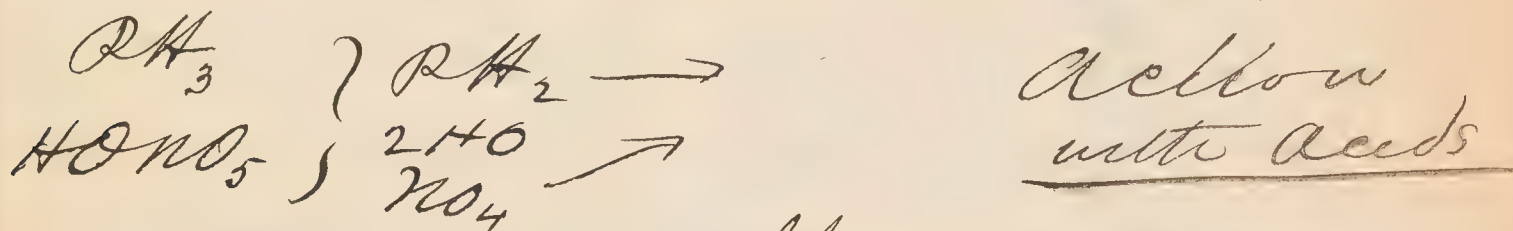
Exp If we lead small bubbles of  $\text{O}$  into  $\text{PtH}_3$  - each one as it comes into contact with the gas burns.

With  $\text{Cl}$  - the same exp experiment can be repeated & the combustion forms  $\text{HCl}$  &  $\text{PhCl}$  etc.

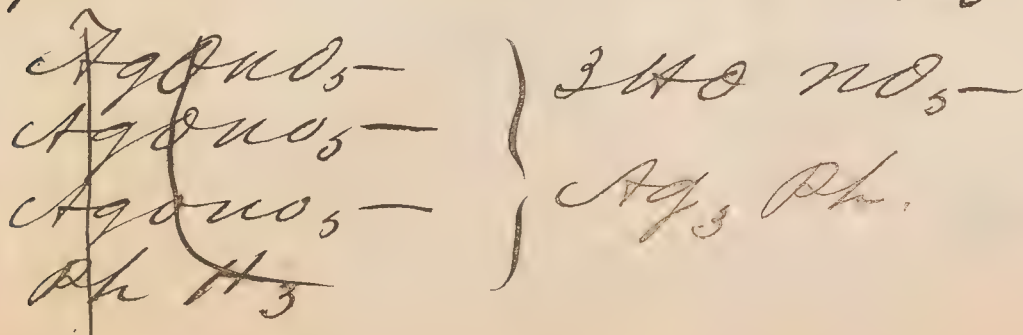
When allowed to stand for a long time - it loses its explosive & combustible



By bringing above a jar Exp  
 of this now combustible  $\text{PH}_3$   
 a glass rod of steeped into  
 fuming  $\text{HNO}_5$  - an instant  
 inflammable issues. It acts  
 to change  $\text{PH}_3$  to the flammable  
 $\text{PH}_2$  hence the combustion: this



It only ~~enters~~  
 enters into combination with  
 One Hydrogen acid: viz  $\text{HCl}$ .  
 & cannot unite with Oxygen  
 acid & forms Salts - : It is  
 so far it has <sup>very</sup> small resem-  
 blance to  $\text{AsH}_3$  - but on the  
 other hand it can form Phos-  
 phides. &  $\text{H}_2\text{O}$  like  $\text{AsH}_3$ .



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Some suppose that the 'Squis Fatius' - above swamps. is produced by this gas. but a scientific description of this very doubtful phenomenon has never been given.

Ph  
+

Phosph. + Oxygen.

O

$P_2O_3, 2H_2O =$  Hypophosphorous acid

$PO_3$  — — — Phosphorous acid

$PO_5$  — — — Phosphoric "

The latter is by far the most important in the laboratory & in Organic World.

Manufactured simply by burning Phosphorous in Ex air. (with excess of air). It

settles upon the sides of the jar in which the combustion



has been carried on in form of a white powder which slowly disappears —

Manuf

It possesses, of all bodies - Proper-  
 the most intense affinity ties -  
 for  $H_2O$  - (although it posses-  
 ses this great affinity it does  
 not dissolve in  $H_2O$  till some  
 time has passed), by slowing  
 the Hydrated  $PO_5$  - all  $H_2O$  goes  
 aff. +  $H_2O PO_5$  - - If tolerable  
 concentration & evaporation - or.  
 by dissol-  
 ving  
 $2 H_2O PO_5$  - + at ordinary con-  
 dition -  $3 H_2O PO_5$  - -  $H_2O PO_5$   
 in  $H_2O$

so that we have three pecu-  
 liar acids.

$H_2O PO_5$  = Monobasic  $PO_5$  -

$\begin{matrix} H_2O \\ H_2O \end{matrix} \} PO_5$  = Bi " "

$\begin{matrix} H_2O \\ H_2O \\ H_2O \end{matrix} \} PO_5$  = Tri " "

The first requires for perfect  
 neutralization 1 atom of base  
 to 1 of acid. the second 2 atoms  
 of base - & the third three  
 atoms of base to 1 of acid.

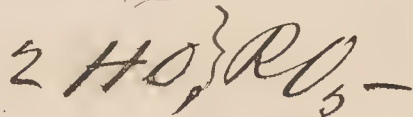


PO<sub>5</sub> -Exp

Manufactured in a flask -  
through which dried air is  
is lead. + it condenses in two  
flasks. + it can be thus be  
obtained in Pounds -

Prop-  
erties

It is when anhydrous - *feuert  
beständig*. when combined  
with H<sub>2</sub>O it is somewhat vol-  
atile. PO<sub>5</sub> has such an af-  
finity for moisture that it  
it will seize the H<sub>2</sub>O even  
from SO<sub>3</sub> H<sub>2</sub>O. Forms as  
has been said 3 Compds  
with H<sub>2</sub>O. —

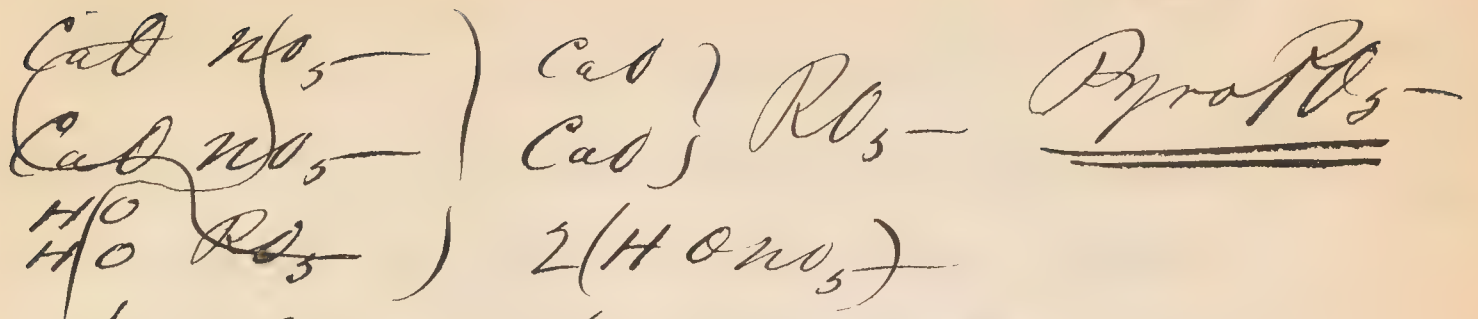
Exp

Manufacture

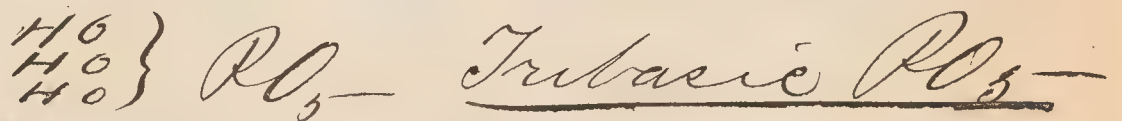
(in)

(by heating)  
3 H<sub>2</sub>O, PO<sub>5</sub> to  
417°C

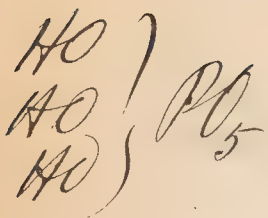
By dissolving HOP<sub>5</sub> in  
H<sub>2</sub>O: these two atoms of  
H<sub>2</sub>O can be replaced by  
as many of a base - form-  
ing basic PO<sub>5</sub> salts



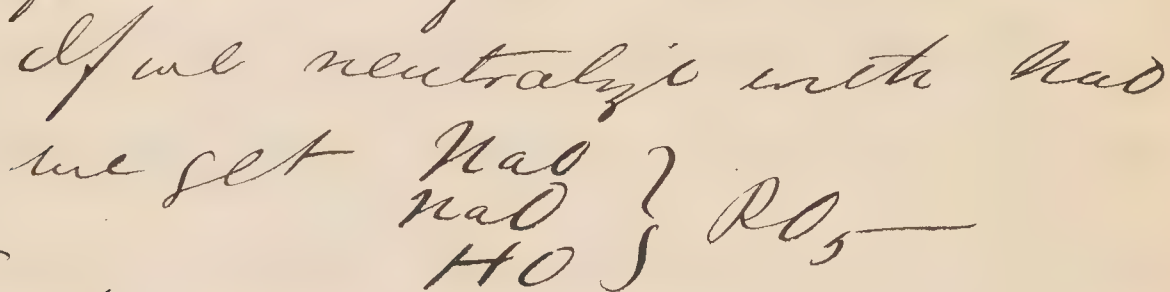
So also with NaO - & this soluble salt - gives a white Precipitate with  $\text{AgONO}_2$  - Tests & this is a test for this acid, & also with Albumen. it gives a white precipitate. Egg  
All the salts of this acid - possess the singular property of being converted into tri-basic salts upon cooking with  $\text{H}_2\text{O}$  for some time



If this acid  $2(\text{H}_2\text{O})\text{PO}_3$  which we have just considered - be cooked with  $\text{H}_2\text{O}$  - it has lost its properties - it gives no precipitate with Albumen ~~except upon addition of some~~ ~~NaNO~~ - then a yellow one.



It has been converted into an acid which instead of two requires three atoms of base to form salts -



Salts

The HO atom can be replaced again by a base be that base NaOH or something else -

These salts when brought with AgO NO<sub>3</sub>, no precipitate results - but when NH<sub>4</sub>NO<sub>3</sub>

Tests

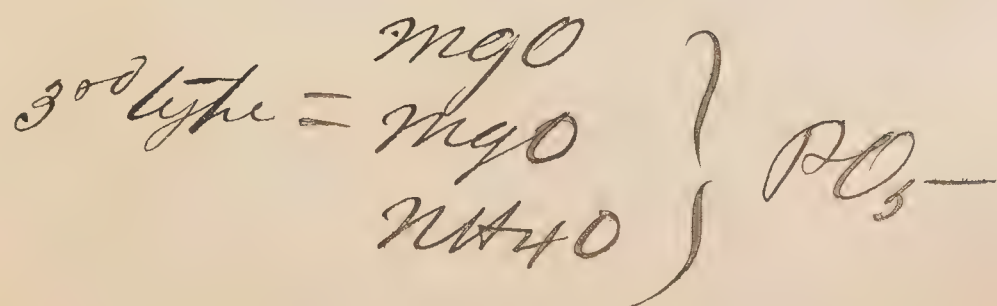
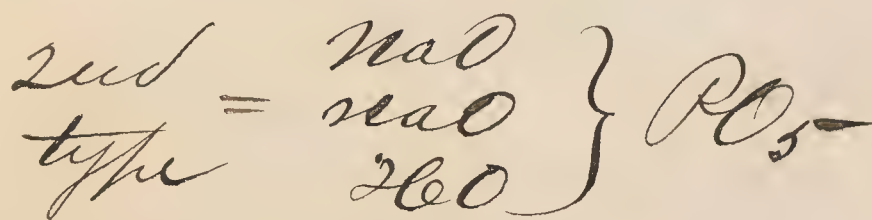
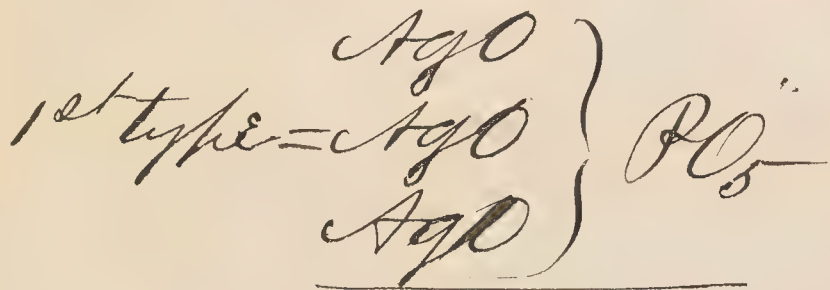
is added a yellow precipitate of 3 AgO, PO<sub>5</sub> -

Albumen brings about no precipitate, + with BaO HO the same result is obtained -

It forms whole rows of



salts - which are characterized by the above named property - they either contain 3 atoms of the Metallic Acide united with  $PO_5$  - or One may be replaced by  $H_2O$  - or the same salt may contain two atoms of one metallic Acide + the third atom may be another ditto - the three types are represented below.



Three  
types  
of  
Inbasie  
 $PO_5$  salts

It may be manufactured  
 Mann - in various ways -  
facture 1<sup>st</sup> As before remarked  
 through boiling of  $\text{H}^{\circ}\text{O}$  }  $\text{P}_2\text{O}_5$  -  
 with excess of  $\text{H}_2\text{O}$  for some  
 time -

2<sup>nd</sup> From  $3\text{CaO}, \text{P}_2\text{O}_5$  - by  
 treating with  $\text{SO}_3, \text{H}_2\text{O}$  -  
 when  $3\text{H}_2\text{O}, \text{P}_2\text{O}_5$  - is expelled,  
 +  $\text{CaO SO}_3$  formed.

In nature all the  
 $\text{P}_2\text{O}_5$  - compounds - Apatite  
Worm Phosphorite - Bones of  
in Animals &c &c, the salts  
 of  $\text{P}_2\text{O}_5$  - in mineral springs  
 + in Plant ashes are all  
 those of Tribasic  $\text{P}_2\text{O}_5$  -

$\text{HOP}_5$  is formed by evap- $\text{HOP}_5$   
oration to dryness + glowing  
the other acids ( $2\text{HOP}_5 +$   
 $3\text{H}_2\text{PO}_5$ ), - It is a glassy-  
white substance. Somewhat  
~~is~~ volatile upon heating.  
It melts with ease - This mel-  
ted mass, resembles glass-  
still more, in being able to  
be drawn out into fine fibers  
threads - At high temper-  
atures it can easily be re-  
duced to a Ph. by C, or He.

 $2\text{HOP}_5$ 

By simply dissolving Mannf  
this  $\text{HOP}_5$  in  $\text{H}_2\text{O}$  - or, action  
by heating  $3\text{HOP}_5$  - above  
 $217^\circ\text{C}$ . The salts are very  
characteristic some of them  
crystallizing finely.



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 $3\text{HOPPO}_5$ 

Is the most important  
of all these acids.

Manuf. Formed by cooking for  
active some time  $2\text{HOPPO}_5$  with  
excess of  $\text{H}_2\text{O}$ .

By glowing with excess of  
 $\text{NaO}$ ,  $\text{CO}_2$  - any Phosphate -

Note

be it a mono - bi or tribasic  
salt will, after glowing, be  
contained as tribasic salt.

Precipitated yellow by  
 $\text{AgO NO}_3$  - in presence of  
a trace of  $\text{NH}_4\text{O}$  - it is

Tests

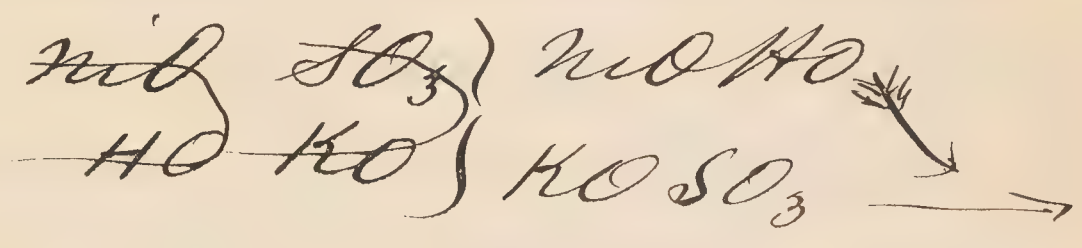
soluble in  $\text{NO}_3$  - +  $\text{NH}_4\text{O}$

Ex

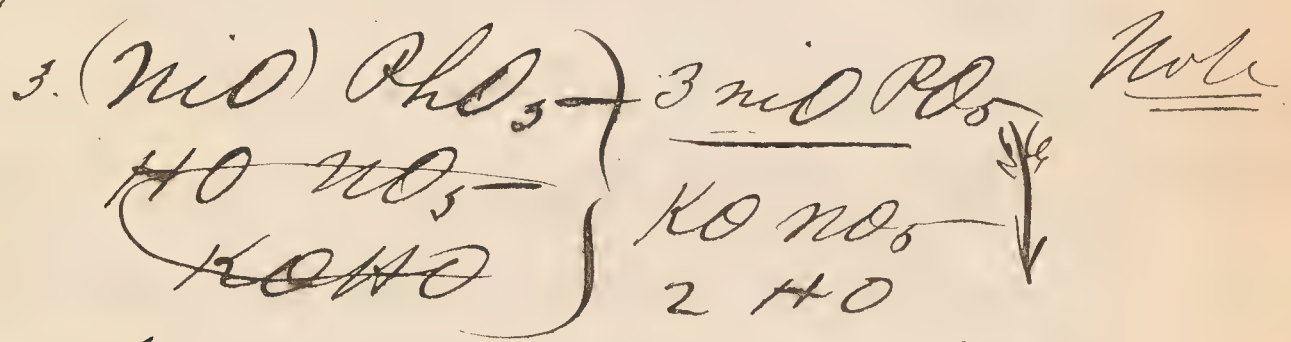
Precipitable by  $\text{BaCl}$  +  
 $\text{PbO A}$  - but soluble easily  
in acids (distinct from  $\text{SO}_3$ )

$\text{PO}_5$  salts are all in  
Difficulty acids soluble - + if then  
of we add a strong base -  
Analysing to the solutions - the phos

phate is precipitated out -  
The ordinary salts behave  
differently - see :-



but



This peculiar behavior -  
is not to be compared  
with any phenomenon  
which any other acid pre-  
sents. Hence it is

necessary to have some  
peculiar reaction for  $\text{NiHO}$ ,  
 $\text{PO}_3$ -salts + we have  $\text{MoO}_3$   
such a one as  $\text{NiHO MoO}_3$   
The  $\text{PO}_3$  must be present  
as Tribasic  $\text{PO}_3$ , + free from  
Organic matters. The  $\text{NiHO MoO}_3$

539 in great excess).  
Test is added to an acid  $\text{NO}_3^-$  solution. left standing for 24 hours  
Filtered - dissolved in  $\text{HNO}_3 + \text{PO}_3^-$  -  
precipitated out by  $\text{MgO}$  mixture

Again - for the instant  
Reaction detection of  $\text{PO}_3^-$  in a body -  
for  $\text{PO}_3^-$  in the we have only to reduce  
Dry Way the 'Dried Compound' with  
Metallic Na or Mg.  $\text{Mg}_2\text{Ph}$

Ex is formed which is decom-  
posed by  $\text{H}_2\text{O}$  -  $\text{PH}_3$  being  
formed, which is recog-  
nized by its smell - the  
glass tube in which the  
test has been made is  
after broken to pieces with a  
Bunsen stroke, & the powder is  
breathed upon - the mix-  
ture of the breath - is  
sufficient to bring about  
the formation of enough  
 $\text{PH}_3$  to detect it easily.



Again:  $\text{PbO}_2$  - possesses Test  
 the property of uniting with Sn  
 in Unknown quantity with Ex  
 $\text{SnO}_2$  - in an  $\text{HNO}_3$  (conc) solution,  
 + of forming a compound  
 $(\text{SnO}_2, x \text{ PbO}_2)$  - which is the  
 only compound of  $\text{PbO}_2$  -  
 which is insoluble in acids.  
 This compound after being  
 freed by washing from  $\text{HNO}_3$  -  
 Can be dissolved in  $\text{KOH}$ ,  $\text{HCl}$  -  
 +  $\text{H}_2\text{S}$  gas lead through -  
 by acidifying, all the Sn  
 is thrown down as  $\text{SnS}_2$   
 + the  $\text{PbO}_2$  is left in solu-  
 tion, it can then be direct-  
 ly Precipitated by Magnesia  
 mixture, or it can, as  
 is generally the case be  
 indirectly determined by  
 weighing the Sn.

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## $PO_3$

Much less important than  $PO_5$  --

Manufac-  
ture

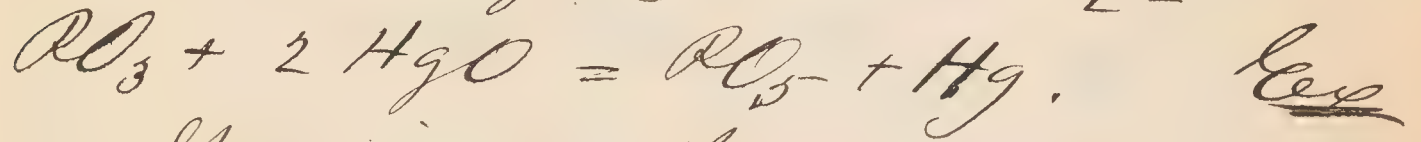
Formed by ~~some~~ treating  $PO_5$  with Ph.  $PO_5$  is then reduced to  $PO_3$ . Or. by burning Ph. in a very small quantity of O.

Properties

It looks like  $PO_5$ . being a solid of white color - which has a great affinity for moisture - & great heat is produced. & the  $PO_3$  is partially or wholly decomposed. It can unite with H<sub>2</sub>O in various quantities -

2(H<sub>2</sub>O).  $PO_3$  - formed by treating Super Chloride of Phosph. with excess of H<sub>2</sub>O & driving off HCl by heating -  
 $Ph Cl_3 + 5 H_2O = PO_3 + 2 H_2O + 3 HCl$

$PO_3$  acts as a reducing agent, forming  $PO_5$  - -  
+ indeed it is somewhat more oxidizing than  $SO_2$  -



It gives with bases definite salts - + indeed of two kinds,

$\begin{matrix} CaO \\ CaO \end{matrix} \} PO_3$  so with  $BaO$ ;  $SrO$  re.  
again with  $MnO$ ,  $MnO$ ,  $CaO$  re.

$\begin{matrix} MnO \\ MnO \\ HO \end{matrix} \} PO_3 \rightarrow$  in which the  $HO$  atom cannot be driven out by mod. heating

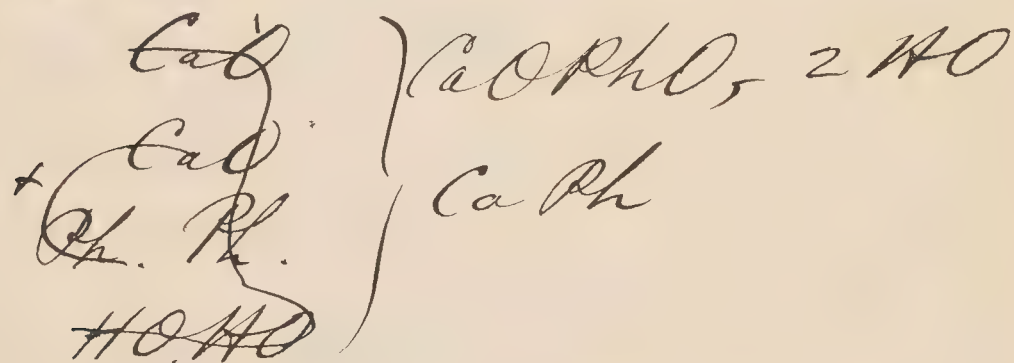
By the slow combustion of P. in air -  $PO_3$  is formed - but it is always impure, being mixed with more, or less  $PO_5$  - - Generally for one atom of  $PO_3$  - two atoms of  $PO_5$  are formed. -  
( $PO_3 - 2 PO_5$  - a compd.?)



manufae PhO - 2HO.

true It is always known with  
2 atoms of HO.

Formed by by Treating  
CaO with Ph - thus: -



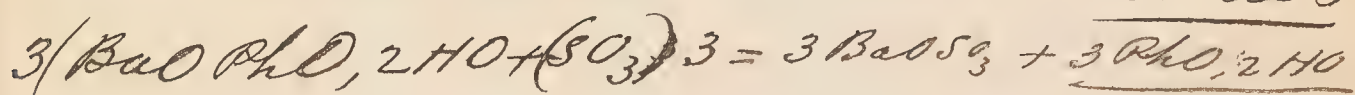
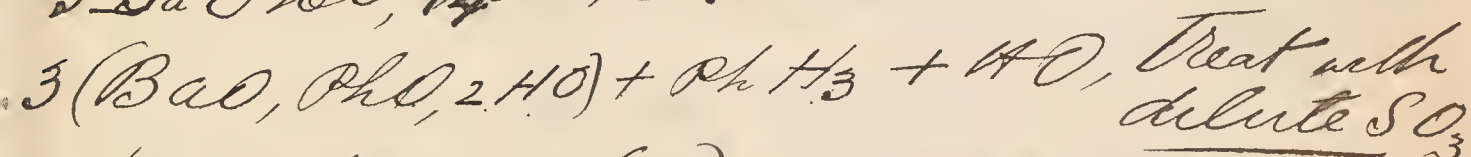
Its properties etc - will  
serve us as our introduc-  
tion for the next lecture,

Lecture 62<sup>nd</sup>.

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PhO, 2HO

By treating CaO, BaO, K<sub>2</sub>O - Mann-  
with Ph. + cooking the fluid. factur



It is a transparent color-  
less, fluid, with an affini-  
ty for Oxidizing itself +  
hence a good reducing a-  
gent. It will be red. Exp  
used to Hg. ~~used~~

PhO. always contains two  
atoms - of HO which can-  
not be substituted by a  
base (two atoms), + hence  
a part of the compound,  
It has been suggested that  
PhO, 2HO was a compound  
of the radical?  $(\text{PhH}_2)\text{O}_3 -$

Use

The Only use which has been made of this compound in the laboratory has been for reducing powers, (in connection with  $\text{HCl}$  or  $\text{HBr}$  - formed)

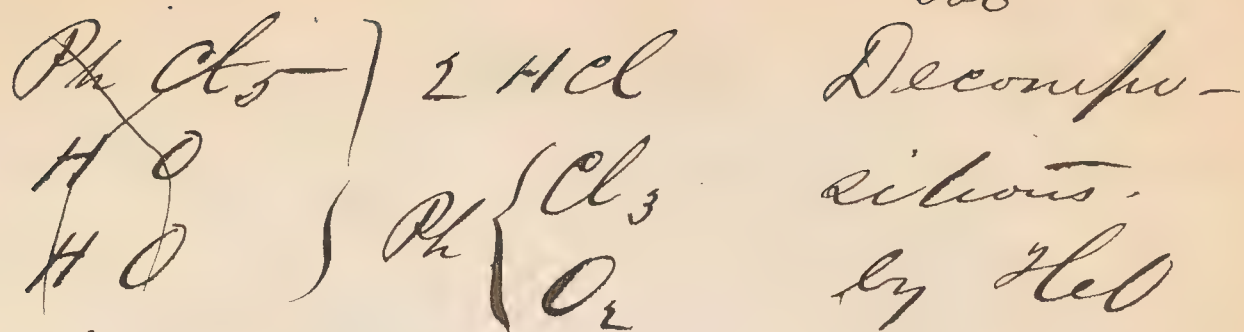


Main facture - By the combination of Ph in Cl. two compounds may be formed. according as Ph. or Cl is present in excess. namely  $\text{Ph Cl}_3$  +  $\text{Ph Cl}_5$  - - -

P. Cl<sub>5</sub>

It is best to dissolve the ~~compounds~~ <sup>phosphorus</sup> in  $\text{CS}_2$ , & in this solution to lead Cl until a solid crystallizable compound begins to separate - that compound is  $\text{P Cl}_5$ . By  $\text{HCl}$  it is decomposed ~~by HCl~~ into several compounds.



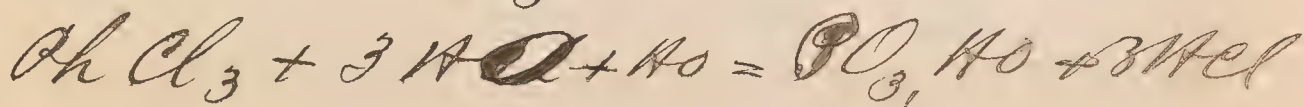


It is interesting on acct  
of the number of ~~decom-~~ Properties  
positions which can be brought  
about by its decomposition  
they belong for the most  
part in the domain of  
organic chemistry.



Manufacture

If we bring Ph. into con-  
tact with  $\text{POCl}_5$  we can form  
the  $\text{Ph Cl}_3$  - it is a liquid -  
& can <sup>be</sup> distilled from the ex-  
cess of Ph. a thin fluid like  
body - it attacks the mucous  
membranes & is fearfully ir-  
ritating. By HCl it decom-  
poses into  $\text{PO}_3 + 2 \text{ HCl}$



Ph + Br.

→ The compds.  $\text{Ph Br}_3 + \text{Ph Br}_2 \rightarrow$   
 $\text{Ph Br}_3 \text{O}_2$  - as with Cl, are brought  
 about in the same way & proper-  
ties are the same

→ Ph + S.

With these bodies we know  
 of a whole list of these com-  
 pounds. In forming them -  
 we always bring the red -  
 (allotropic Ph) into contact  
 with the S. If we sh'd attempt  
 to combine ordinary Ph. with  
 S. we sh'd. expose ourselves to  
 great danger, for all these  
 compounds are much more <sup>exp.</sup> ~~eff.~~  
 flammable than P. & much more  
 easily inflamed - we can  
 form the compds by direct  
 union of the elements & it sh'd  
 be carried on in a glass flask  
 in an atmosphere of  $\text{CO}_2$   
 where exists →  
 $\text{P}_2 \text{S}$ .  $\text{PS}$ .  $\text{PS}_3 + \text{PS}_5$

P + N.

568.

A remarkable compound  
noted for its indifference  
is  $\text{Ph N}_2$ , formed by treating  $\text{Ph N}_2$   
 $\text{Ph Cl}_3$  with  $\text{NH}_4\text{O}$  - & then  
heating the resulting compound  
 $\text{Ph Cl}_3 \text{ NH}_4\text{O} \rightarrow (\text{Ph N}_2?) + 3\text{HCl} + \text{H}_2\text{O}$   
a white powder - of earthy Prop-  
Consistency - perfectly indif- fer-  
ferent - & non-volatile - a  
remarkable exception to  
the generality of N, compounds  
which are fearfully explosive.

As.

Processes much more resem-  
blance to Ph than to N. - Occurrence  
It occurs in the Earth as  
metallic As. then as Arsenides  
( $\text{Co As}_2$  -  $\text{Ni As}_2$   $\text{Fe As}_2$  &c &c)  
Again - as Arsenates ( $\text{Ni O AsO}_3$  -  
 $\text{Co O AsO}_3$  &c &c) - lastly as  $\text{As}_2\text{S}_3$  &  
 $\text{As}_2\text{S}_5$  - Arsenic & Realgar.



From these compounds, the metallic arsenic is manufactured as follows.

By heating the compounds.

Manufac. (arsenides) the As is sublimed, & is then sublimed in the higher parts of the retort (Chimney) in Iron vessels prepared for the purpose with  $AsO_3 + As_2O_3$  compounds. The ones are mixed with Coal & then the same process is followed.

As + Metallic As occurs in two Allotropic Modifications. Ordinary As is black with Metallic lustre.

1 An Allotropic As -

The latter can be obtained like the allotropic Ph. viz: by heating As for some time at about  $250^\circ$  - & by very slowly cooling the ~~the~~ sublimed As will be found too

have been converted into an  
amorphous mass without me-  
talic lustre - By sudden <sup>allotropic</sup>  
heating + sublimation it is <sup>re</sup>  
converted into ~~As~~ Ordinary As  
As - (just as allotropic as)  
The allotropic as, is not so  
easily altered by Contact  
with air - (just like allotropic  
Ph) as the Ordinary As.

By throwing upon Coal  
it is volatilized + gives out  
a peculiar odor - like Garlic  
important to be noticed as Smell  
it is important as a test of As.  
for this substance. All the  
Compounds of Arsenic are  
poisonous, without excep- Poison-  
tion - One grain is about as dan-  
gerous as sufficient to poison a <sup>adult</sup> of  
man. As Compds

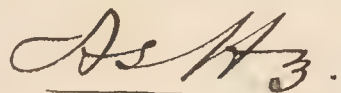
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The Metal ~~+ its salt~~ is  
Exp very volatile, + by heating  
 in a tube, it condenses as  
 a metallic mirror at the  
Mirror top, Another important  
 fact to be remembered in  
 testing for this substance  
As & O It combines with Oxygen -  
 easily (slowly at ordinary  
 temperatures), + forms  $AsO_3$   
 It supports therefore Combustion  
Exp → it burns in Oxygen  
 flame, vice versa Oxygen  
 → can be burned in  
 Arsenic vapor. (Burn in  
As vapor - Cu - Zinc, Pb - no  
 evolution of light - that is  
 no glowing, so with Pb +  
Exp only the metals of the first  
 group - Na K + give bright light

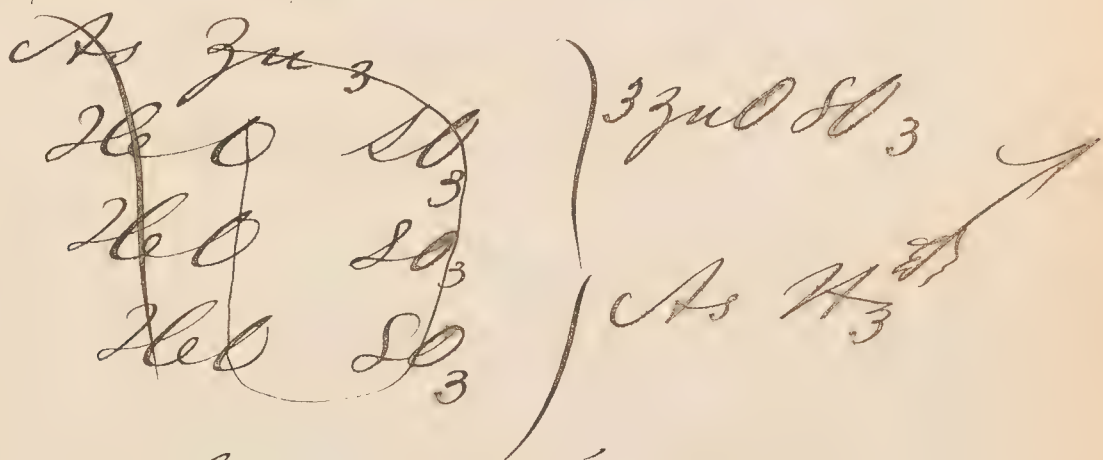


As + H compounds.

There are probably two compounds - but only one has been examined viz -



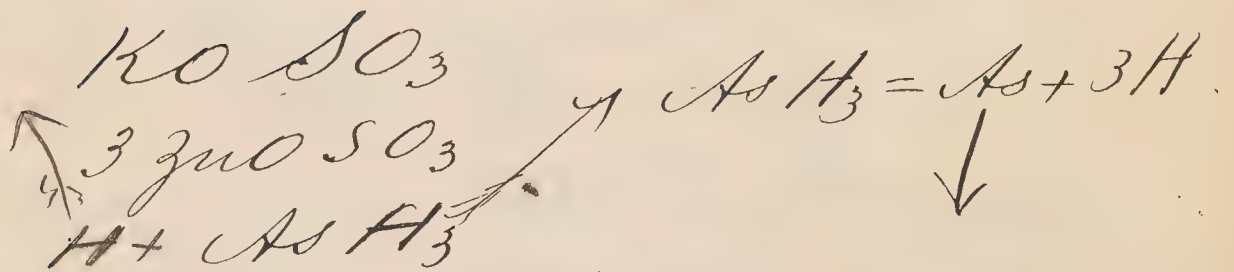
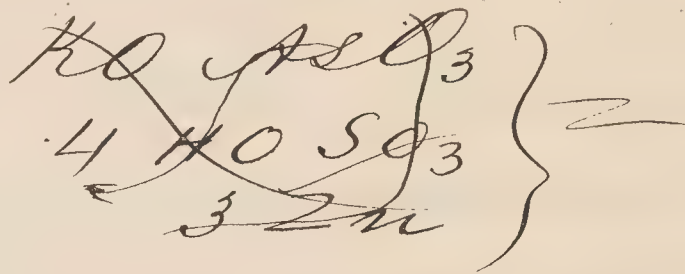
Formed by smelting together As + 3 Zn - + then treating this alloy with a hydrated acid.



Again - by treating any soluble salt of AsO<sub>3</sub> (or AsO<sub>5</sub>) with zinc + dilute HCl - The same compound is formed - along with Zn<sup>2+</sup> With HCl, by holding it in contact with a dry + cold surface

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Test. of Porcelain - it is de-  
 by composed into As which  
~~AsH<sub>3</sub>~~ is deposited in the form  
 of a metallic lustrous  
 mirror - + into H<sub>2</sub> which  
 escapes. → thus -



This too is an important  
 test for As compds. &  
 in legal examinations -  
 a very or divany one.

Lecture 63<sup>rd</sup>

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(A.S. H3)

Properties

The gas is so decomposable that in contact with  $H_2O$  it is decomposed - the Oxygen contained in it being sufficient to oxidize the H, + A.S.

The discoverer of this gas became ~~was~~ ~~was~~ victim to its poisonous properties. He incautiously & ignorantly inhaled, some of its fumes - & died in a week - from Chronic As poisoning.

Hel. Br. I & c. will all decompose this gas. Decompos.

It burns in air with a <sup>subl.</sup> its pale blue flame, if burned with an insufficient supply of air, it smokes just as Exp a Hydro Carbon. The smoke will be deposited upon



Dry, porcelain as As.

The gas is neither acid nor base, but is like  $\text{PH}_3$  neutral.

Qual. By bringing a measured quantity above a vessel  
Yes of  $\text{CuSO}_4$  &c, the salt will be decomposed &  
Ex Cu As formed, & the amt of  $\text{H}_2$  left behind can be measured. We know the sp. gr. of the original gas, & from the weight of  $\text{H}_2$  can get the atom. i.e. constitution.

### As + O.

AsO<sub>3</sub> = Arsenious acid.

AsO<sub>5</sub> = Arsenic acid.

both analogous to the corresponding Oxides of N + P. As<sub>2</sub>O<sub>3</sub>.

Manu-  
facture

It always formed when As is burned in air - it

settles upon cold surfaces,  
 It is not known in combi-  
 nation with  $H_2O$  - being very  
 little soluble - In Heat  $H_2O$   
 it is much more soluble <sup>solu-</sup>  
 than in cold  $H_2O$ , <sup>bility</sup>  
20 parts of cold  $H_2O$  contain -  $H_2O$ ,  
 1 part of  $As_2O_3$  - Heat  $H_2O$  somewhat more.

When thrown in a pulver-  
 ized condition upon  $H_2O$  - Ex  
 it mixes with great diffi- note  
 culty with it, & often gives  
 cause for the detection of at-  
 tempts at poisoning - It swims in  
particles upon the surface.

$As_2O_3$  crystallized from  $H_2O$   
 in regular system in  $O$  <sup>Dimor-</sup>  
 with Diamond lustre - phy

It is also dimorphous for  
 together with these regular Cryst-  
 als - there are sometimes found  
 flat-lamella-like forms - so

577.

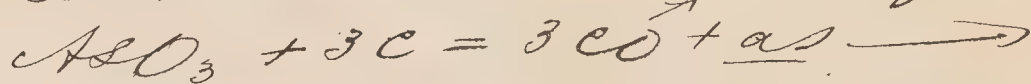
imperfect, however, that  
the crystal form is diffic-  
cult to be determined -

Prop-  
ties

AsO<sub>3</sub>, by heating volatilizes  
+ sublimates itself, again  
as AsO<sub>3</sub> - In volatilizing  
the acid gives out no  
smell - (Metallic as does).

Exp

Thrown upon Coal - it  
gives the usual smell of  
As - for the Carbon reduc-  
es the AsO<sub>3</sub> to metallic  
as - which diffuses the  
smell so characteristic of it



If we bring <sup>into</sup> a solution of  
Test AsO<sub>3</sub>, a stream of H<sub>2</sub>S  
gas - (partic. in acid solution)  
we obtain a yellow  
precipitate of As<sub>2</sub>S<sub>3</sub>. this is  
what is called a Sulph-



578.

acid. + possesses the prop-  
erty of dissolving in Sulph. A sulpho-  
bases (for ex. K.S.), forming <sup>an</sup> S. Salt Acid.

Again, with  $\text{AgONO}_2$  (+  $\text{HNO}_3$ ).  
 $\text{AsO}_3$  salts give a yellow Ex  
precipitate of  $\text{AgO AsO}_3$   
which is soluble in ex-  
cess of  $\text{HNO}_3$  or in acids.

With  $\text{CaO H}_2\text{O}$  a precip-  
itate of  $\text{CaO AsO}_3$ . a poor Ex  
test for it is not brought  
out in dilute solutions  
+ in the presence of  $\text{HNO}_3$   
salts is not formed.

### $\text{AsO}_5$ -- Properties

$\left. \begin{matrix} \text{HO} \\ \text{HO} \\ \text{HO} \end{matrix} \right\} \text{AsO}_5$  It is known  
anhydrous - +  
in solution.  $\text{H}_2\text{O}$   
dissolves more of it than of  $\text{AsO}_3$   
It is formed by oxidation  
of  $\text{AsO}_3$  with Agua Regia  
or  $\text{NO}_5$ .

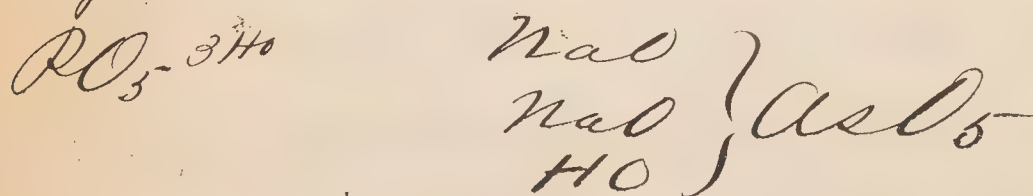


579.

It is likewise a violent  
poison - but  $AsO_3$  seems  
to act more energetically.

Bober- The Acid is tribasic, after  
the type of  $PO_3$  -

It gives a whole row of beau-  
tifully crystallizing salts  
hydrate after the following type



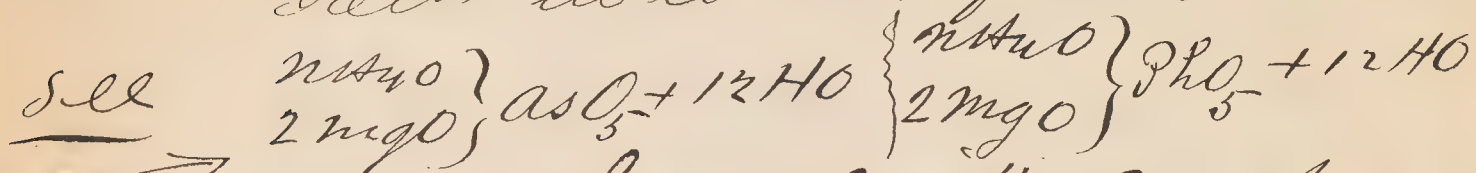
is the general type of its Salts  
Singular as it may  
seem, the salts of  $AsO_3$  -  
can be heated very consid-  
erably without losing their  
Oxygen or As. Hence  
we always, in quantita-  
tive analyses of this sub-  
stance form this salt,  
for this we can heat to drive  
off  $H_2O$ , etc & then weigh it.

$AsO_5$  behaves very differ-ently from  $AsO_3$  - It is not precipitated by H<sub>2</sub>S - Ice (except by warming + leading a continuous stream for some time - S is separated +  $As_2S_3$  precipitated), but by reducing with  $SO_2$   $AsO_3$  salts which then sweeten precipitate. With  $AgONO_3$  - it ex likewise gives a precipitate - (better in presence of some  $NH_4O$ ), but the color is Chocolate brown - like  $AgO AsO_3$  it is soluble in  $NH_4O$  + in acids. Isomorphism

The salts of  $AsO_5$  - are all isomorphous with  $PO_5$  - A remarkable similarity exists in the salt of  $AsO_5$  - with  $MgO$  +  $NH_4O$  - + with



387.  
that of  $\text{PO}_5$  - with the same  
bases. we always form these  
salts in testing for  $\text{PO}_3$  or  $\text{As}$ .



In all its Compounds

$\text{AsO}_3$ ,  $\text{AsO}_5$  - &c &c, as is

Flame easily recognized, by bring-

Reac- ting a comp'd in the light  
tions portion of Bunsen's lamp -  
of & ~~tellur~~ directly above it

Bunsen holding a dry porcelain  
surface, - it then ~~condense~~

in condenses upon it as met-  
allie  $\text{As}$ ; in the first tra-  
ces, this reaction can be  
brought about - & the met-  
allie coating can be tested -  
in the usual way -

The Acide  $\text{AsO}_3$  can be for-  
med - & can be converted in-  
to  $\text{As}_2\text{S}_3$  -  $\text{As}_2\text{S}_5$  &c. These can  
be tested - &c &c.

The  $As_2O_3$  can be dissolved <sup>582.</sup>  
in  $K_2S$  (or rather  $MnS$ ) - See

$As_2O_3$  can be precipitated upon  
the 'Schale' by a drop of  $H_2O$ ,  
 $NO_3^-$  (+  $MnO$ ) - + all the reac-  
tions brought about as usu-  
al in the laboratory.

It is often of the greatest  
importance to the Chem- The  
ist to be able to decide impor-  
tance  
with the sharpest accu- of  
racy, whether traces of As As  
are present in any body tests to  
or not - for in legal ex- the  
aminations, the life or Chemist  
death of a human  
being may depend upon  
the answer of the experimen-  
ter. The procedure is  
then as follows -

1st all the reagents - used  
in the operation must be

The proc. thoroughly tested, & the  
 test by entire absence of traces  
 As pois- of Arsenic in them, es-  
tab-lished, before they are  
 used in the operation.

The proper search for the  
 presence of the poison then  
 commences. The As. must  
 be searched for in the con-  
 tents of the Stomach, &  
 the intestines, & in the sub-  
 stance of these organs, & in  
 the other perfect organs -  
 viz: the liver, <sup>Spleen</sup> Lungs, & in  
 what might have been vom-  
 ited; in the urine & faeces.

It may in some cases be ne-  
 cessary to examine remains  
 of suspected food; or vessels  
 in which the suspected food  
 might have been kept.



Practice in a Case of Arsenic pois-  
 In other cases - papers &c &c. oning.  
 must be examined. ~~Body~~<sup>with</sup> bod. Contain-  
 is long buried, & hence far used.  
 gone into decomposition - it  
 it is necessary to examine  
 the earth in the immediate  
 neighborhood of the Corpse for  
 the traces which could have  
 found their way thence from  
 the body.

In the chemical investigation  
 the first operation is a  
Careful investigation of the  
contents of the Stomach & in-  
testines; the above mentioned  
 parts are 'spread out' in a  
 number of new, & clean por-  
 Cellain dishes - & made to  
 cover a large surface - with  
 newly made glass rods -

Ditto

+ now the whole map carefully examined with the aid of a <sup>contents</sup> 'magnifying glass' + the ~~parts~~ are turned about with the glass rods. Above all, one must, have his attention fixed for the presence of 'small white hard Particles' or grains, which may be undissolved particles of  $As_2O_3$  - these are carefully removed from the mass with the pincers, + placed in a separate dish for examination. These particles are found in the most cases in the folds of the mucous membrane of the stomach + the intestines, By diluting the contents of the stomach + intestines with  $H_2O$  - or better - with

by  $H_2O_2$ , it sometimes serves to enable us with ease - to Ditto. separate, from the stoned & examined organic matter - which is generally light - a considerable amount of the  $AsO_3$ , which settles to the bottom -

The Aim of the Chemist in all these chemical investigations is to place before the 'Legal examiners' the Arsenic in substance - & indeed - as Metallic Arsenic. Only in this form, in which it possesses such highly characteristic properties - that it cannot possibly be mistaken for any other substance - Can it be brought into Court - For in this form, the merest



Ditto

quantities, such as cannot be weighed, or acct of their minuteness, cannot be mistaken. + only in this form placed before the Committee (or jurors) can they accept the researches of the Chemist as legal evidence of the presence of As. all other compounds & forms are 'legally' worthless, however characteristic & conclusive they may be for the Chemist himself.

This isolation of As in metallic form is very simple even when traces are present; But the greatest difficulties present themselves, when the problem is (as it usually happens to be), to separate

this minima of As, from this Great mass of organic matter - & to separate it in such a form that metallic As can be won from it.

To illustrate the process, the Chemist can best follow, we shall divide, the cases into Three possible ones. to include all that may come vor.

1<sup>st</sup> The As & exists yet in substance in the Contents of Stomach & intestines, or the Vomited matter.

2<sup>nd</sup> It is intimately mixed & invisible, or is dissolved up in & mixed with the Contents. & hence - not perceptible in substance & non-separable by mechanical means.

3<sup>rd</sup> The Stomach & intestines

As  
 poison-  
ing

are empty - or the examination failed to show any: it is therefore absorbed in the blood or into the organs.

### 1<sup>st</sup> Case -

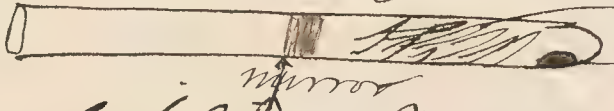
The  $AsO_3$  has been found in Subst. Arce. It is separated from the Organic Matter by washing - & recognized by the following prop.

1<sup>st</sup> They are white - or colorless - seldom clear & translucent - hard & brittle -

2<sup>nd</sup> A particle, however, small - when heated in a small test tube (but long) - will volatilize & Condense above in the form of a fine powder of white color. which when examined, with a magnifier - are found to be composed of Octahedrons.



3<sup>rd</sup> Strew upon Coal they give  
the Garlic odor of As.

4<sup>th</sup> A particle is brought into  
a  $\frac{1}{8}$  thin tube + long - upon  
it are thrown thin splinters of C  
(previously glowing) - then the  
C is heated - + lastly the As.  
grain - 

The  $As_2O_3$  volatilizes passes over  
the Coal, is reduced to metallic  
As + is deposited in the colder  
part of the tube as a mirror of  
metallic arsenic. By heating  
the mirror it can be made  
to pass all over the tube +  
settle down again - as the  
lamp advances: (upon breaking  
the flap + burning the Garlic smell  
is made apparent).

5<sup>th</sup> The same experiment  
can be performed by Marsh's Apparatus

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Ditto

6<sup>th</sup> Heat a particle with a small quantity (pin head) of acetate of KO - + the antracene smell of Kakodyl will be made apparent.

7<sup>th</sup> Dissolve particles in H<sub>2</sub>O by boiling them in a pulverized Condition - + perform the precipitations with AgO NO<sub>3</sub> - + CuO SO<sub>3</sub> &c.

II Case. The As is not present in 'Appreciable' quantity - but is dissolved, or ~~is~~ intimately mixed with the contents of the Stomach.

In this case the contents the Stomach itself + the intestines must separately be examined, + the latter two - destroyed by decomposing reagents. Forst may be important to know

how far the poison has penetrated into the system. (Also some medicines Antimonialia. Acetum Phos. murat. + sulph. by careless preparations can have contained As.) The Contents - are then treated with saturation with Cl Gas - + the excess of Cl driven off + then the whole filtered - + as must be in the fluid.

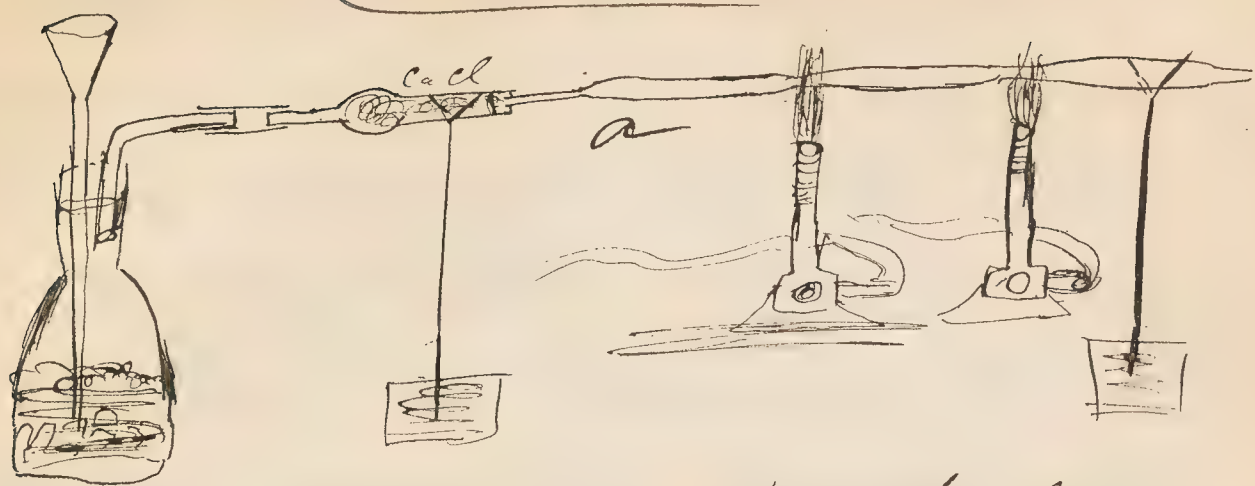
The Stomach + intestines are cut into small pieces, + spread equally out in a 'Schale' - ( $\frac{1}{3}$  always reserved for accidents) Covered with tolerably Conc. KOHO, + digested so long, until it is completely depolished - then slightly acidify with  $\text{SO}_3$  + add to saturation Cl Gas. Warm the fluid - + pass  $\text{H}_2\text{S}$  to complete saturation Sulphide of As is obtained -



Ditto

impurified with Organic Matter.  
 To free it bring  $\text{NO}_2$  - into contact  
 with it in a shell - & evaporate  
 to dryness. (after the whole is  
 dissolved & the  $\text{NO}_2$  - has been  
 neutralized by  $\text{NaO CO}_2$ ) -  
 Upon this evaporation all organ-  
 ic matter is gone & a white  
 Crystalline  $\text{NaO AsO}_3$  is left  
 behind, This can be tested  
 by all the possible ways men-  
 tioned.

Or: the whole Organic mass -  
 can with fluid contents & all -  
 be brought into a retort - with  
 $\text{NaCl}$  - (equal weight) &  $\text{SO}_3$  cone  
 added. As  $\text{Cl}_3$  distills over into  
 the vessel. It can be either brought  
 at once into Marsh's Aparat. or -  
 first precipitated with  $\text{H}_2\text{S}$ . This  
 last method is the simplest & best.



Marsh's apparatus. The flask contains  $\text{Zn} + \text{HOSbO}_3$  + the fluid containing  $\text{AsO}_3$ .  $\text{H}$  gas +  $\text{AsH}_3$  are generated by the  $\text{HOSbO}_3$  — The latter is decomposed by the heat of the lamps + settles beyond the heated parts as metallic  $\text{As}$  — the well known 'mirror of  $\text{As}$ ' The tube <sup>a</sup> can be then melted off at various places + the metal retained in hermetically sealed tubes for presentation or further examination.

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Tested 1<sup>st</sup> for volatility & the  
smell. 3<sup>rd</sup> the oxidation is carried  
out, so that the black deposit  
is changed to a white one.

4<sup>th</sup> This is examined by the magni-  
fier - for the Octahedrons of  $\text{FeSO}_3$   
5<sup>th</sup> Dissolve the  $\text{As}_2\text{S}_3$  in  $\text{HCl}$  &  $\text{H}_2\text{O}$  -  
& make the reactions in the  
wet way. (See previous lecture)

The next important subject  
in the consideration of As -

Antidotes is the subject of antidotes  
for this specialty & in general.  
Parsons He can do away <sup>with</sup> the effects  
after various poisons by  
converting the same into  
other compounds which  
are not poisons - or by pro-  
ducing an insoluble compound  
which the fluid & organs of  
the body cannot assimilate



596.

With Organic Compounds  
it is different. Here we have  
three elements  $C H + O$  generally  
in combination, & they are by  
far the most dangerous of all Poisons

With inorganic poisons it  
is generally one compound  
or one element that is dan-  
gerous. so we speak of  
Pl. poisons - Hg. & Cu pois.  
onium - As ditto. &c. Antidotes

There is a general & univer-  
sal method of procedure  
in procuring a proper an-  
tidote for any poison, viz:-

The poisons, to be such, must  
be taken into the animal &  
be dissolved - & our business  
is to change these soluble  
compounds - into insoluble  
ones. which the fluids of the  
body cannot assimilate.

& which will therefore remain harmless in the stomach & intestines till they pass from the body.

Anti-  
doles

We have only to search for a most insoluble compound of the poisonous element & administer the reagent which produces this insoluble precipitate.

The antidote itself however must fulfil certain conditions  
1<sup>st</sup>. It must not be itself a poison — for it is always necessary to administer it in large excess, & it itself would produce death.

2<sup>nd</sup>. The antidote must act quickly — it must instantly stop the action of the poison — before it proceeds further.

With As poisoning - we should have three usual-  
 ular Compds which we might bring about -  
 $\text{CaO AsO}_3$  -  $\text{As}_2\text{O}_3$  -  $\text{AgO AsO}_3$   
 The first of these -  $\text{CaO AsO}_3$   
 would not do as an antidote  
 for it does not fulfil the second  
 Condition neces. for an antidote  
 viz: It does not act rapidly - & again  
 $\text{CaO AsO}_3$  is somewhat soluble.  
 The second, Compd - Could  
 not be formed - for the only  
 reagents, by which we could  
 bring about this Compd - are  
 in themselves poisonous, & hence  
 no antidotes - The third  
 Compd - formed by  $\text{AgO AsO}_3$  -  
 is open to the same ob-  
 jection - in a far more in-  
 tensified condition.



599

Recd

For As. we have, however,  
An antidote, which fully meets

$\text{Fe}_2 \text{O}_3$  every demand upon it -

$3\text{H}_2\text{O}$ , + which has even, in the last

+ a trace stages of Poisoning by this

of  $\text{NH}_4\text{O}$

substance - proved complete -

ly serviceable.  $\text{Vz} : \text{Fe}_2 \text{O}_3, 3\text{H}_2\text{O}$

Hydrated sesqui-oxide of Iron

It can be administered by  
the powder without danger,

+ completely, + rapidly re-

moves from the body all

traces of As. forming a

Compd - ( $\text{Fe}_2 \text{O}_3 \text{ As}_2\text{O}_3$ ) -

By treating a solution of

$\text{As}_2\text{O}_3$  with excess of  $\text{Fe}_2 \text{O}_3, 3\text{H}_2\text{O}$

+ filtering at once - no trace

of As remains behind - for

H. S. - shows no precipitate -

A brilliant experiment -

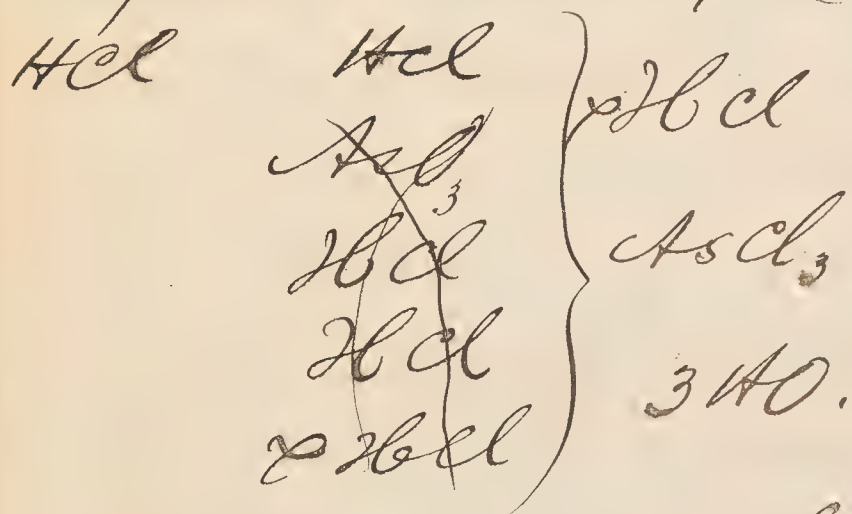
before a class.

Ex

$AsCl_3$ 

We only know of one Compound of  $As$  +  $Cl$ , it is perfectly analogous to the corresponding salt of  $Ph$  - It is a colorless,

heavy liquid, giving out fumes, formed by passing  $Cl$  over  $As$  - or by treating  $AsO_3$  with very concentrated, + (an excess of)



It is very-poisonous, + very volatile.

With  $H_2O$  it is completely decomposed into  $AsO_3$  +  $3HCl$



Formed by one method of legal examining for  $As$  poisoning.

601

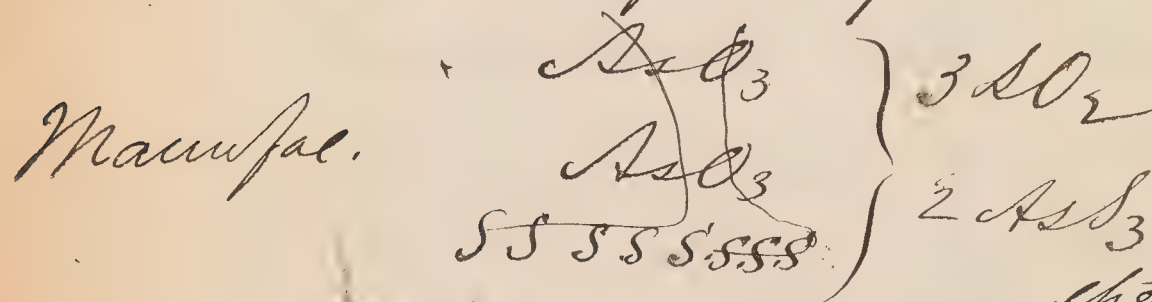
# Arsenic + Sulphur -

We know of two compounds  
 Arsenic of Sulphur + Arsenic -  
 ment Both of which occur in na-  
 +  
Realgar ture - viz.  $AsS_3$  - +  $AsS_2$

Beside then occurs a compound  
 unknown in nature -  $AsS_5$  -

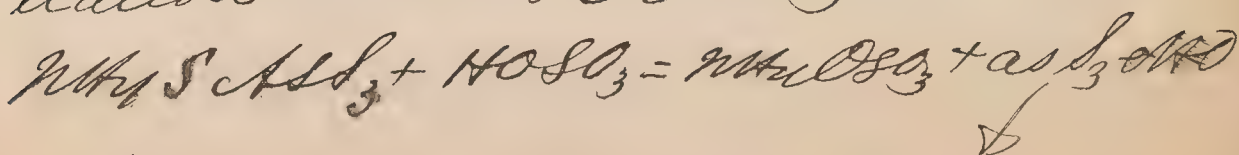
## $AsS_3$

Formed in manufactures  
 by smelting  $AsO_3$  with an  
 excess of sulphur -



It is very impure, being  
 often as much as 40 per cent  
 $AsO_3$  mixed with it.

From its solution in  $NH_4SH$   
 it can be purified by precip-  
 itation with  $HOSO_3$





## Realgar, $As_2S_3$

A solid - red in color - occurs  
Crystallized in nature -  
Formed by smelting together  
the constituents in their  
proper proportions. -

$As + N.$

There is such a compound -  
which however - is of no impor-  
tance - formed by a similar  
process as the correspond-  
ing compound of  $P + N$ .

## Antimony (St.)

External appearance  
precisely like a metal -  
It resembles in its chemical  
character arsenic very much.

$StS_3$  - (Stibic-glanz) - in nature

is frequently found workmen  
very pure, & from this  
it is most generally obtained.

603.

This is almost the only  
Mineral from which -

Main Sb is obtained

facture It is manufactured by  
driving off the volatile Sb  
by Heat

It likewise occurs al-  
ways accompanying

As Compds. as an isomor-  
phous constituent, + this  
renders the purification  
of either metal a mat-  
ter of much difficulty -

Both metals being vol-  
atile

It is won, as follows -  
The Grawspessglazey is -  
is freed from the Gangue  
by smelting - + then roas-  
ted in air. whereby the Sul-  
phur burns off, + the

Oxidized  $SbO_3$  remains behind - this is mixed with  $C$ , &  $KO$ ; & heated for some time to red heat - whereby the  $Sb$  separates as regulus.. See The  $Sb$ , thus, obtained is impure never pure, but contains with  $As$  - small traces of  $As$  - &  $apb$ ,  $Fe$  &  $c$ . (It is important to know that  $Sb$  contains  $As$  - for it is much used in medicine. To purify it from  $As$  - by smelting with  $110$  - its quantity of  $KON_3$  - ~~+~~ by which the  $KOAsO_3$  formed remains in the slag as such &  $Sb$  remains free from  $As$  behind as regulus.



605.

Lecture 65<sup>th</sup>

At ordinary temperatures  
it is beständig.

Oxidation agents oxidize  
it to Antimonous Acid.

Ex It burns in air or oxygen  
with a green light.

Oxygen will burn also in  
Sb vapor. By the combustion  
in Oxygen - air etc - white  
& thick vapors of  $SbO_3$ .

This  $SbO_3$  is also amorphous  
the ordinary form is not  
the regular Octahedron but  
needles in some other system.

Sb.

Perfectly analogous to  
As.  $SbH_3$ .

A similar Compound to  $SbH_3$   
but has not yet been  
accurately studied.

Manufactured by treating SnH<sub>3</sub>  
 Zn Sb. br with  $\text{HOSO}_3$  -  
 Or, by evolving Hydrogen  
 with zinc +  $\text{HOSO}_3$  - + then  
 adding a solution contain-  
 ing Sb to it: - it is then ob-  
 tained. It is like  $\text{AsH}_3$  - Exp  
 a gas - colorless, etc, + easily  
 decomposable, It burns with  
 a greenish flame ~~like~~ -  
 then ignited, + the flame  
 is brought against a  
 wet + dry surface of Mirror  
Porcelain - we obtain like  
 just as with arsenic - AsH<sub>3</sub>  
 a metallic mirror -  
 There are, however, certain  
 tests by which the identity  
 of this deposit can be de-  
 termined.

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Ex.

Can give Metallic Sb by  
bringing a metallic oxide  
into contact with it.

With  $\text{As}_2\text{O}_3$  - 3 B.

By leading through a  
glowing tube it is decomposed  
just as  $\text{AsH}_3$

Antimony + Oxygen

$\text{Sb}_2\text{O}_3$  = Antimonious acid

$\text{Sb}_2\text{O}_5$  = Antimonic acid

$\text{Sb}_2\text{O}_4 = \text{Sb}_2\text{O}_3 + \text{Sb}_2\text{O}_5$

The first is analogous to  
 $\text{P}_2\text{O}_3 + \text{As}_2\text{O}_3$  - in formula  
+ in general chemical  
character -

The second corresponds to  
 $\text{As}_2\text{O}_5 + \text{P}_2\text{O}_5$  -

The third - is probably  
nothing but a combination  
of the other two, for it shows  
the properties of both.



608.

SbO<sub>5</sub>Properties  
& manuf.

Can be simply formed by  
Oxidizing Sb - with  $\text{NO}_3^-$  (conc)  
by act of heat.

Again - By smelting Sb with  
 $\text{KNO}_3$  or  $\text{KClO}_3$  - + ~~sol~~ dis-  
solving out the flux - the  
first is the simplest method  
+ saves us the trouble of decant.

tation + removal of KCl or K<sub>2</sub>SO<sub>4</sub> -  $2\text{K}$

There exists besides this SbO<sub>5</sub>  
acid yet another having  
the formula  $\text{RO} \begin{Bmatrix} \text{O} \\ \text{O} \end{Bmatrix} \text{SbO}_3$  - -  
formed by fusing with excess  
of base. The first gives  
difficultly soluble salts +  
the latter soluble salts - +

the method of distinguish-  
ing between them is that Tests  
 $\text{NaO SbO}_3$  is precipitated from  $(\text{NaO SbO}_3)$   
soluble monobasic salt by  $\text{NaCl}$  while  
Bibasic  $\text{SbO}_5$  does not give precip.

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Prop-  
erties

The  $\text{SbO}_2$  (anhydrous) is very  
difficultly soluble - insol. in  
 $\text{H}_2\text{O}$  - in  $\text{HCl}$  - + only slight-  
ly soluble in Aqua regia.

→  $\text{SbO}_4$

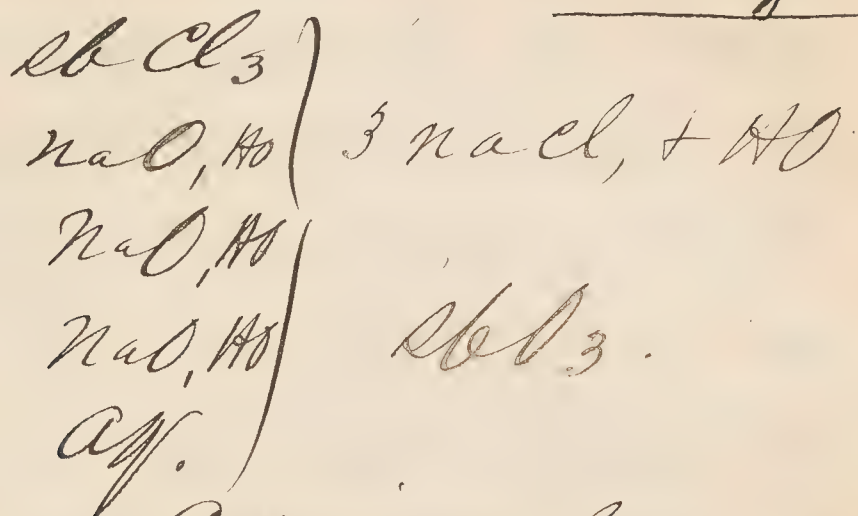
Do:

$\text{SbO}_2$  can combine with  $\text{H}_2\text{O}$   
+ form  $\text{SbO}_3$ ,  $\text{SbO}_3 = \text{SbO}_4$   
Formed by fusing strongly  
ordinary  $\text{SbO}_2$  - it possesses  
the properties of both the  
acids -  $\text{SbO}_3 + \text{H}_2\text{O}$  - by smel-  
ting with  $\text{K}_2\text{O}$ , it gives  $\text{KOSbO}_3$   
+  $\text{K}_2\text{O SbO}_2$  (infusible +  
both  $\text{SbO}_3 + \text{SbO}_2$  are unfused  
beständig - like  $\text{PO}_3$  - -

→  $\text{SbO}_3$

By ~~smel~~ heating  $\text{SbO}_2$   
with metallic Sb (just as  
Manufa. ture  $\text{PO}_3$  was formed by heating  
 $2\text{SbO}_2$  with  $\text{Pb}$ ). we obtain  
the same oxide  $\text{SbO}_3$

By treating  $SbCl_3$  with  $NaOH$   
in  $H_2O$  solution. Manufacture



Again - by simply  
burning  $Sb$  in air.  $Sb_2O_3$   
is formed. (like  $As_2O_3 + PbO_3$ )  
The  $Sb_2O_3$  melts + is some-  
what volatile - a differ-  
ence from  $Sb_2O_4 + Sb_2O_5$  -

By treating with  
 $H_2S$  -  $Sb_2O_3$  is precipitated with  
as  $Sb_2S_3$  as a reddish precip.

( $Sb_2O_5$  gives identically the  $Sb_2S_3$   
same colored precipitate - a sul-  
as  $Sb_2S_3$  - both are sulpho phospho  
acids + dissolve in basic  
sulphides  $K_2S$  or  $Na_2S$ ,



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To distinguish between  $SbCl_3$  +  $SbCl_5$  is the fact that  $SbI_3$  - does not precipitate. By treating  $K_2O$ ,  $SbCl_5$  with  $KI$  - a yellow precipitate of  $SbI_3$  + Iodine is set free.

By  $SbCl_3$  salts the same yellow precipitate is formed - but no Iodine is set free. a good method of distinguishing between them.

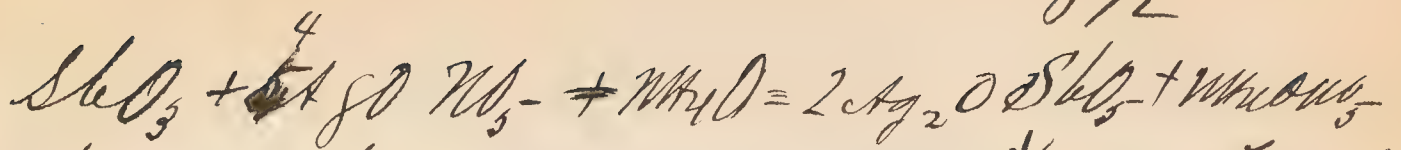
Bunsen's Flame test Coating of  $Sb$  - (insoluble Reac- in  $HgCl_2 + NaCl$ ?).

tion. Or the oxide  $SbCl_3$  by which

we can show the reaction with  $AgNO_3$  +  $NH_4O$

Distinction. which gives us a safe indication of the presence of  $Sb$  - + distinguishes it from  $As$ .

6/2



The reaction only takes place <sup>↓</sup> to dis-  
in Alkaline solutions - as <sup>↑</sup> in quench  
the free  $\text{NO}_2$  must be <sup>↑</sup> between  
neutralized by an alkali  $\text{Sb} + \text{As}$   
to form the salt of  $\text{Ag}_2\text{O}$ .  
The sulphide ( $\text{SbS}_3$ ) can Ex  
likewise be formed - + its  
color indicated - as a disting-  
uishing Prop. from  $\text{AsS}_3$  -  
but the prime test is the  
above mentioned reac-  
tion with  $\text{AgNO}_3 + \text{NH}_4\text{O}$ .  $\text{Sb}$  gives  
something  $\text{Sb}$  poisoning or onion  
Cure + as we get the same  
black deposit as in the  
case of  $\text{As}$ , but the distinc-  
tions already mentioned make  
it easy to distinguish be-  
tween the two substances

Keep

<sup>13</sup>  
Get the mirror as before  
by a series of lamps just  
as with Cs. + subject  
the same to the usual  
tests to distinguish Ab.

Those tests as necessary  
for legal examinations  
will be given in the next  
lecture



6/4.

# Lecture 66<sup>th</sup>

The mirror is somewhat Exp different from that of As. resting but not enough to make the it a characteristic test. Mirror.

1<sup>st</sup> The Mirror is not volatile like As, but upon oxidation - it will apparently volatilize & condense as  $\text{SbO}_3$  this powder - however is not crystalline, but amorphous.

These differences, however, are not characteristic enough for the detection of small quantities - the absence of the As smell - is somewhat more characteristic - but still not of sufficiently certain nature. If we now dipolve up - this  $\text{SbO}_3$  in  $\text{HCl}$  & make the precipitation by  $\text{H}_2\text{S}$

615.

Testing  
the  
Mirror

we get a reddish precipitate; but with small quantities, this is not characteristic enough, & ~~at~~ when traces of As are present - apt to be deceiving.

But - a characteristic reaction with the Sb mirror - to distinguish it from As - is the fact that As is soluble in  $\text{NaOClO} + \text{NaCl}$  - (freshly prepared best), while Sb - is not soluble - a very good distinction.

A yet better reaction is that of the flame reactions & particularly the deposits of  $\text{SbO}_3$  - & with this to bring about the AgNO}\_3 reactions (it can be done at the same time with

Exp

$AsO_3$ , & the two compared.  
this is the best reactions).

A very important matter, is  
next the analytical separation  
of  $As$  &  $Sb$ , which frequently separa-  
tion is necessary in the laboratory.  
The best method, is that of  
Bunsen - & is grounded upon  $As$  &  
the fact that, by treating the  $Sb$ .  
solutions of the sulphides -  
( $AsS_3$  &  $SbS_3$ ) in  $KS$  with  $Cl$   
an excess of  $SO_2$ ,  $H_2O$ , & boil-  
ing until the smell of  $SO_2$  is  
no longer perceptible - a sol-  
uble salt  $KOAsO_3$ , is formed  
while - the  $SbS_3$  is precip-  
itated - as such with much  
separated sulphur. The  $KOSbS_3$   
can be filtered off, & the  $SbS_3$   
separated from the  $S$ , by  $CS_2$  -  
& then tested at leisure, & determined.



$Sb + Cl + Br \text{ etc.}$

$SbCl_3$  <sup>2er</sup> = Chloride of Antimony

Prop.  $SbCl_5$  = Super Chlorid. " "  
+  $SbCl_3$  formed just like  $PbCl_3$

Manu. Or, simply by dissolving  $Sb_2$  in  
factum  $HCl$  + evaporating + distilling.

$SbCl_5$  by letting  $Cl$  act upon  
 $SbCl_3$  (just as  $PbCl_5$  from  $PbCl_3$ )

$SbCl_3$  is a solid crystalline  
substance -  $SbCl_5$ , a yellow  
oily liquid - which fumes  
in the air. It can change  
these compounds into one another  
 $SbCl_5$  by letting  $Cl$  act upon  
 $SbCl_3$  - + the latter by letting  
 $Sb$  - act upon  $SbCl_5$  -

The former ( $SbCl_3$ ) is very  
caustic - + is much used  
as medicine - called - brown  
its consistency Butter of  $Sb$ .  
+ much valued.

By treating these Chlorides Oxy  
with  $H_2O$  - a number of Chloride  
Oxy Chlorides are formed, which  
do not allow themselves  
to be separated from one another  
or

$2 SbCl_3 + 3 H_2O = SbCl_3, SbO_3 + 3 HCl$ .  
The salts of Sb - are much used  
in medicine.

Sb + Br. + d. unimportant  
Sb + S.

$Sb_2S_3$  = Ter. Chloride of Sb.

$Sb_2S_5$  = Per " " "

Properties  
+

$Sb_2S_3$  - is a orange yellow mass.  
powder - by gentle heating fact.  
it melts - + by slow cooling  
it crystallizes.

It dissolves in  $H_2O$  as  $Sb_2O_3$  -

+ separates partly as brown  
 $Sb_2S_3$  + partly as  $H_2O Sb_2O_3$

By heating in the air, it

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burns to  $SbO_3 + SO_2$  -

$SbS_5$  -

A somewhat darker. Denser  
Calves substance than  
 $SbS_3$  - It forms many beau-  
tiful crystallizable salts -

There are also compounds  
of  $Sb$  +  $Fe$  compounds -

He might at this place <sup>take up</sup>  
Bismuth, for it presents  
many analogies to  $Sb$ , but  
it will be consid. under other Metals

Carbon.

Known from all historic  
time - & will beschäftigen  
us for some. as the com-  
pds of  $C$  are more numer-  
ous than, all the other  
Compds of which Chemistry  
knows - taken together. we  
can only pick out the import. ones

$SbS_5$

Car-  
bon



All the numberless compounds  
in Organic Chemistry are  
compounds of C. with H + O &c.

+ an extended consideration  
of them belongs to that branch  
of Chemical science. we can  
only give them cursory course, Carbon

Very widely spread in Nature  
& in Celestial bodies.

Pure it is seldom found;  
only as Diamond it is  
found pure - likewise very  
fine as Graphite in many  
parts of the world. differs  
from Diamond only in Crystal form  
Then as a compound Car-  
bon appears in  $\text{CO}_2$  - un-  
spread in nature, & playing  $\text{CO}_2$   
a vastly important role in  
the economy of Plants & Animals.

O<sub>2</sub>/

This substance occurs again  
as an ingredient of Limestone  
( $\text{CaO CO}_2$ ) + of dolomites  
 $\text{CaMg CO}_2$  ( $\text{CaO CO}_2$ ) which form  
+ ( $\text{MgO CO}_2$ ) mountain mas-  
Dolomite ses of thousands of feet  
in thickness, + which are  
spread in all quarters of  
the world.

Plants again. Carbon is an ingre-  
+ dient of all the animal  
Animals tissues - + the existence  
of the animals + Plants - de-  
pends upon the mutual  
action of each: the one  
giving out as refuse product  
 $\text{CO}_2$  - + the other deriving  
its nourishment from this  
product - + giving back  
to the atmosphere the  
Oxygen for the sust. of animals

One occurrence of Carbon Coal  
of the vastest importance to the Fossil  
social condition of mankind. Plants  
has been omitted till now.

+ That is the occurrence in  
the form of Coals of various  
kinds, of fossil plant remains.  
This occurrence is a mark  
of the independence + strength  
+ progress of modern nations.

Many regions are only made  
habitable by man, through  
its occurrence there + &c, &c, &c.

In this form Carbon is never  
pure - but contains impurities  
of various kinds - H + O + N

+ organic matter of various  
kinds, more or less abundantly.  
Many kinds of Coal are distin-  
guished - Anthracite, Bituminous.  
Canal coals &c, &c.



Peat Its occurrence is not con-  
 fined to the 'Carboniferous Age'  
 & their as geologists formerly supposed  
 formed but it has been found in va-  
 rious conditions of purity in  
 nearly every formation - the  
 older the age of its occurrence  
 the purer is the coal. (Silu-  
 rian Anthracite of Rhode Island)  
 It is found in Tertiary depos-  
 its - & in various parts  
 of the world (Ireland partic)  
 it is being yet formed  
 on a vast scale. The Peat  
bogs as they are called are  
 the ground upon which the  
 Coal format. is continually being  
 made, & it can be dug up from  
 them, in all the various stages  
 from 'hardened brown coal', to  
 half decayed mass - & through

these to all the intermediate  
 stages. All these bogs - are  
 upon land, at low levels -  
 & which at some seasons Great  
 after years are inundated, bogs.  
 The plants are mosses &  
 ferns, mostly, which (former)  
 possess the ability of growing  
 in their upper part, while  
 the lower parts are totally  
 decayed. It can readily be  
 imagined that where slow  
 sinking of the earth accom-  
 panies, the growth of these  
 plants - immense accumu-  
 lations of vegetable remains  
 can in time be brought  
 about —

---

Lecture 6<sup>th</sup>

Carbon also occurs ~~in~~ as asphaltum: after great value in the preparation of Illuminating gas. Burns after some access when removed from the flame.

Pure Carbon comes in ~~natural~~ three amorphous conditions, the most remarkable instance of Allotropic - of which Chemistry can boast. They are as follows: —

Allotropic-  
ic Con-  
ditions  
of  
Carbon,

1<sup>st</sup> Diamond.

2<sup>nd</sup> Graphite

3<sup>rd</sup> Charcoal. (better Organic Carbon)

Diamond.

less sparingly spread in nature  
+ only in certain quarters of  
the world - Particularly in  
Brazil, India, Ceylon



It crystallizes in the regular  
 system - O. 20, mon <sup>in</sup> tetra, various  
 combinations of the first system. Diamond,  
 Color very variable - from  
 white to black - refracts light pecu-  
 liarly. Is the hardest of known  
 substances. infusible except in <sup>workmen</sup>  
 the oxy hydrogen blow-pipe -  
 Product of Combustion -  $\text{CO}_2$ .  
 (Sir H. Davy). Most of the diamonds  
 are found loosely <sup>among</sup> in the sands  
 + pebbles of river beds, in the diamond  
 countries - (in secondary beds) - only  
 since a few years, has the orig. Properties  
 and source from which they come  
 been discovered - it is Stacoliomite  
 (a schistose mixture of Quartz - + <sup>dark</sup> ~~Mass~~  
~~schist~~). The workings for Diamonds  
 in this rock, in Brazil, was  
 given up on acct of its impro-  
 ductiveness.

Dia-  
mond

Crystallizes in the regular system - in modified forms of the Octahedron.

It is the hardest of known bodies. + is hence is used for cutting, + drawing upon glass - + for grinding its own substance - by its powder

Of these three modifications of Carbon; Charcoal is the easiest to inflame, Diamond is the next. + Graphite, the most difficult.

The product of Combustion in all these cases is the same.

Diamond is the most valued of precious stones - the art of grinding + polishing them was discovered by Otto von Guericke. it is done, as above mentioned with diamond dust.

The worth of diamonds unlike the worth that of any other merchandise of Diam. increases with the weight - not directly, but as the weight increases - the price is squared.

They are of all colors - from Colors of transparent - to perfectly Diamonds black - the latter are singu- Hardness. larly enough, the hardest.

This is most difficult. (except Graphite) modifie. of Carbon - to inflame - then ~~free~~ heated to white heat in a bed of Coal - (Charcoal) it is converted into the second modification of C. viz: Graphite. By changing the conditions again we can convert this Graphite into amorphous Carbon - but we have not yet been able to convert either of these last into Diamonds.



a lot - if we could find a solvent  
 agent for Carbon, we could easily  
 for C. produce large samples of  
 Diamonds. We know of two,  
 but they only take it up at  
 enormously high temperatures  
 & it crystallizes out in the  
 form of Graphite. These  
 two substances are Iron  
 & Aluminum.

### Graphite

Occurs in nature - Produced from  
 the other modifications by expo-  
 sing them to <sup>the</sup> highest temper-  
 ature which we can produce  
 then it forms upon cooling  
 a crystalline - black solid, of  
 metallic lustre, which can be  
 called the metallic modification  
 of C. so also by the cooling  
 of Raw Iron Graphite separator

Graph-  
ite

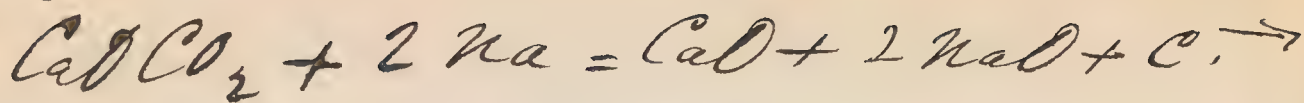
Crystallized. It is utterly different from the Diamond. Properties

It is non-transparent - of metallic lustre, black color - very soft. One of the softest minerals known while Diamond is ~~one~~ <sup>the</sup> hardest. It crystallizes in the Hexagonal system, Di. Graphite  
amond, in the regular -  $\text{H}_2\text{SO}_3$   
treated, with  $\text{H}_2\text{SO}_3$ , it is Ece  
upon evaporation left plastic  
Mixed with Clay - it is used - use  
for lead pencils, + for Caprilles.

Organic C (Charcoal) - Amorphous C.

For mankind - by far the most important. - it is distinguished from the ~~best~~ other modifications by its easy inflammability. Exists impure - in wood fibre - formed pure - by heating a carbonate Cop  
with K. or Na, + heating -

63/.



Thus it is obtained free from the ashes as we plant.

It is <sup>a</sup>black - opaque - &

mainly. perfectly amorphous mass -  
facture is not known in crystalline form; For analysis & reduction in the laboratory - we keep always prepare the Carbon - in the following way.

Turpentine The place, above a lamp of burning Turpentine Oil, a smooth, coal surface of porcelain. (Heat a large porcelain dish of cold H<sub>2</sub>O) the unconsumed Carbon is deposited upon it, in the form of an intensely black, impalpable powder - by slowing it, it can be freed from the fumes. & rendered pure.



















